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LIST OF PLATES.

PLATE		FACING PAGE
I.	Portrait of Sir John Evans, K.C.B., F.R.S.	1
II.	Map of Towan Head and Newquay, Cornwall	11
III.	Nun Cove, Newquay, Cornwall	17
IV.	Carboniferous Corals	74
V.	Carboniferous Corals	74
VI.	Carboniferous Corals	150
VII.	Flowing Well, Kharga Oasis, Egypt	162
VIII.	Portrait of H. C. Sorby, LL.D., F.R.S.	193
IX.	Skull and Mandible of *Prozeuglodon atrox*	209
X.	Section of Tooth of Labyrinthodont Reptile	241
XI.	Sketch-map of Federated Malay States	284
XII.	*Receptaculites*, Girvan	296
XIII.	Rock Sections, Lurcombe, Newton Abbot	350
XIV.	*Typhlonisceus* and *Zygospira*	436
XV.	Croft Quarry, Leicestershire	353
XVI.	Bardon Hill and Croft Quarries, Leicestershire	355
XVII.	New Chalk Crinoids, Seaford Head, Sussex	357
XVIII.	The Pau Valley and Silurian Slates	368
XIX.	Rock Sections, Gavarnie District, Pyrenees	424
XX.	Upper and Lower Old Red Sandstone, Whiting Ness and Seaton Point	406
XXI.	Upper Old Red Sandstone, Cove Haven, Seaton Bay	408
XXII.	*Haliserites Dechenianus*, Göppert, Silurian, Gippsland, Victoria, Australia	440
XXIII.	Figs. 1–3, end of Left Humerus of *Macacus* sp., Fresh-water Bed, West Runton, Norfolk; Figs. 4, 5, Horn-core of *Gazella Davidsii*, Hinton, Norwich Crag, Bramerton	445
XXIV.	Dentition of *Cynognathus crateronotus*	484
XXV.	*Lebetodiscus*	550

LIST OF ILLUSTRATIONS IN THE TEXT.

PAGE

Diagrammatic view of cliffs, Headland Hotel, Newquay, Cornwall . . . 15

Transverse section of *Zaphrentis omaliusi*; tabula of same represented by contours 23

Map of Northern Kharga, Egypt 51

Section through Kharga Oasis 53

Zaphrentis delanouei (vertical section) 65

Outlines of *Zaphrentis konincki* 69

Diagrammatic sketch of Raised Beach, Newquay, Cornwall 82

Right innominate bone of *Myargyctes fapeto*, gen. et sp. nov., Forsyth Major . 98

Section Lower Keuper Sandstone, Guy's Cliff House, Warwick 100

Section on opposite bank of Avon 101

Section in large quarry, Bromsgrove, Worcestershire 102

River-windings, figure-of-8 loop 110

Deviation of a river towards a tributary 112

Map of Tiverton District 151

Section from Morebath, near Dulverton, to River Clyst 153

Outlines of *Caninia cornucopiæ* 160

Transverse sections of *Caninia cornucopiæ* 165

Left humerus of *Dinodocus Mackesoni* 205

Plan of Worgret Hill 213

Section at Worgret Hill 214

Eastern face of excavation for reservoir at Worgret 218

Section through the Dorset Syncline, showing position of Bovington Borehole 246

Section showing well, headings, and borings, Bournemouth Waterworks . . 250

Cervical vertebra, *Scaphonyx Fischeri*, A. S. Woodw., gen. et sp. nov. . . 252

Dorsal vertebra, *Scaphonyx Fischeri*, A. S. Woodw. 253

Digit with four phalanges, *Scaphonyx Fischeri*, A. S. Woodw. 254

Ungual phalange, *Scaphonyx Fischeri*, A. S. Woodw. 255

Map of quartz-felsite exposures, Carnarvonshire. 264

St. Agnes Earthquake, Cornwall 299

Carnarvon Earthquake 300

Derby Earthquake 302

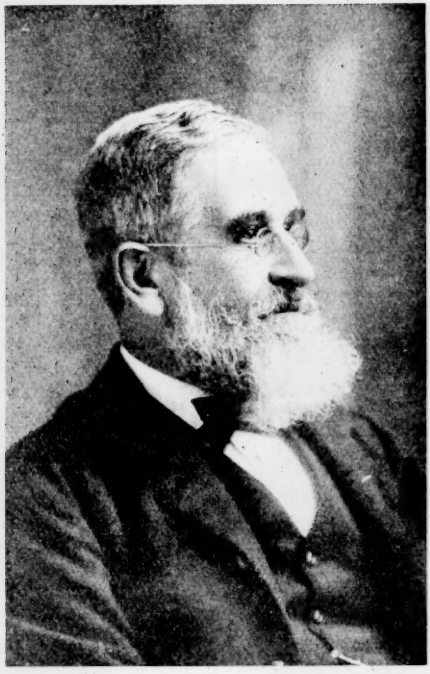
Western side of Tygerberg-poort, Cape Colony 311

Diagram of Tygerberg Range 312

'Lambeau' of Witteberg quartzites *in situ* 312

PAGE

Pollicipes nalensis, Richardson, sp. nov. 352
Section across the Gavarnie overthrust 361
Map of Gavarnie District, Pyrenees 363
Structure of the lower part of the Pic de Mourgat 364
Præanaspides præcursor, H. Woodw., gen. et sp. nov. 385
Præanaspides præcursor, H. Woodw. 386
Præanaspides præcursor, H. Woodw. (abdominal segments, telson, and uropods) 388
Gampsonyx fimbriatus, Jordan & v. Meyer 389
Acanthotelson stimpsoni, M. & W. 390
Palæocaris typus, M. & W. 391
Anaspides tasmaniæ, G. M. Thomson 392
Sketch-map of the Geology of Forfarshire 397
Map of outlier of Upper Old Red Sandstone, Arbroath 405
Diagram of increasing temperature 423
Sketch-section through middle of South Africa 425
Hipponyx dibleyi, Sherborn, n.sp. (Figs. 1, 3), White Chalk, Cuxton, Kent . 457
Hipponyx blackmorei, Sherborn, n.sp. (Fig. 2), Chalk, East Harnham, Salisbury 457
The Hooghly River below Calcutta 448
Continuation of the Hooghly River 449
The River Exe (Topsham to Exmouth) 452
Diagrams of rivers with stable channels 454
Loricula Darwini, H. Woodw., sp. nov., Middle Chalk, Rochester . . . 493
Loricula pulchella, var. *minor* (after Fritsch) 494
Sketch-map, Petrography of Egypt 502
Woodcut, Glen Roy 525
Page-map of part of Oxfordshire 530
Subvective skeleton of *Lebetodiscus Dicksoni* 545
Cyclus simulans, F. R. C. Reed, sp. nov. 551
Ideal section through Vredefort Massif from Parys, W.N.W. 558
Permanent magnet with adjustable poles 560



yours faithfully

John Evans

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. V.

No. I.—JANUARY, 1908.

ORIGINAL ARTICLES.

I.—Eminent Living Geologists:

Sir John Evans, K.C.B., D.C.L., LL.D., Sc.D., F.R.S., F.S.A., F.G.S., F.C.S., F.L.S., F.Z.S.;

Assoc. Inst. C.E., late V.P. and Treas. R.S., For. Sec. Geol. Soc., Pres. Roy. Num. Soc., Trust. Brit. Mus., Hon. M.R.I. Acad., Hon. F.S.A. Scot., Corr. Inst. France and of the Acad. of Sciences of Bologna, Comm. Ord. St. Thiago, Port., Officer of the Order of St. Charles of Monaco, etc., etc.

(WITH A PORTRAIT, PLATE I.)

FEW men who have engaged successfully in commerce for nearly half a century have achieved so distinguished a position in the world of science as Sir John Evans. Indeed, it may be said that his keen intellect, which enabled him to excel in business affairs, also gave him enormous advantages in pursuing those branches of natural knowledge to the investigation of which he has devoted his long life and his remarkable abilities, ever combining "science with practice." His powers of observation have always been singularly acute, and the writer recalls vividly a walk across the open country in Hertfordshire years ago, in his company, with Professor Boyd Dawkins and the late W. Ayshford Sanford, and being struck with the rapidity with which John Evans's well-trained eye detected a flint implement on the stony surface of a stubble-field, overlooked by the rest of the party.

John Evans, son of the late Rev. Arthur Benoni Evans, D.D., was born at Britwell Court, Burnham, Bucks, 17th November, 1823, and moved as a child with his parents to Market Bosworth, Leicestershire, on his father's appointment as Head Master of the Grammar School, in which he at once commenced to study. His first introduction to Geology was at the early age of 9, when hammer in hand he paid a visit, in June, 1832, to the famous "Wren's Nest" and Wenlock Limestone quarries at Dudley; there he found his first fossils, and returned home rejoicing and laden with spoils. In 1839 he was sent by his father to Germany for seven months to study the language, and in 1840 he left school and entered upon a business career at Nash Mills, Hemel Hempstead, where he was initiated into the art of paper-making under the firm of John Dickinson & Co., of which his uncle, the late J. Dickinson, F.R.S., was senior partner. It can easily

be imagined that in such a business mathematical, mechanical, chemical, and geological knowledge might all be most valuable aids, and so it proved, for in 1851, when but 28 years of age, John Evans became a partner in the firm. About this time a celebrated lawsuit, Dickinson *v.* The Grand Junction Canal Co., turning on the question of water-supply, led him to pay still more special attention to geology than heretofore, and in this inquiry he had the good fortune to establish a warm personal friendship with Mr. (afterwards Sir) Joseph Prestwich, which lasted to the end of the latter's life.

Besides the question of water-supply and the Tertiary and Chalk formations, in which Prestwich was from an early period the great authority, and to which from that time forward John Evans also devoted most earnest attention, they had a common interest in collecting and studying flint implements from the gravels and other superficial deposits, in which, following the late Joshua Trimmer, Prestwich undertook the task of classifying and synchronising the strata, named by him 'Quaternary,' as Evans did with regard to the flint implements contained in them, and Falconer in respect to their associated mammalian remains.

In 1852 John Evans became a Fellow of the Society of Antiquaries, of which Society 33 years later he was elected President, holding the chair for seven years (1885–92).

In 1841 M. Boucher de Perthes began to collect, and in 1847 to publish his researches in the gravel deposits of the Valley of the Somme around Abbeville, and the sight of his collection incited Dr. Rigollot to search the gravel-pits around Amiens, which also yielded abundant evidence, in palæolithic flint implements, of the former presence of prehistoric man. It was the part taken in 1858–9 by Falconer, Prestwich, Evans, Lubbock, and others which at length secured for Boucher de Perthes the recognition that he deserved for his labour in the field of prehistoric archæology, which heretofore had been denied him by his countrymen in France. Then old records were unearthed, and it was ascertained by John Evans that about the year 1700 bones of the Mammoth (*E. primigenius*) had been found together with a flint weapon made by primitive man in Gray's Inn Lane, London.[1] He also recalled and republished Mr. Frere's account of the finding of flint implements with remains of Elephant, Rhinoceros, and Hippopotamus, in the Valley of the Waveney, at Hoxne, 1797.[2] So long ago as 1824 the Rev. Dr. John Fleming in an article in the Edinburgh Philosophical Journal (vol. xi) advocated the contemporaneity of the human and animal remains found in cave-deposits; and the exploration of Kent's Cavern before Pengelly's days by the Rev. J. McEnery, in 1824, led to the discovery of flint implements of undoubted human workmanship, with bones and teeth of the Mammoth, the Machærodus, Rhinoceros, Cave Bear, and other mammals, but McEnery distrusted his own discoveries at that time as being doubtfully contemporaneous.[3]

[1] Evans, "Stone Implements," 1872, pp. 521–2.

[2] See "Flint Implements from the Drift," 1859; also *Geologist*, 1861, vol. iv, pp. 20–1.

[3] Geol. Mag., 1902, pp. 116–117.

The change in public opinion in this country was no doubt largely due to the results obtained by the systematic investigation of Brixham Cave, near Torquay, commenced in 1858 under the direction of a Committee of the Geological Society, upon which John Evans served, with Prestwich, Falconer, Ramsay, and Busk, the actual carrying out of the work in the cave being entrusted to William Pengelly.

His subsequent exploration of Kent's Cavern, Torquay, initiated by Sir Charles Lyell, when President of the British Association in Bath (1864), and carried on for years by a powerful committee on which John Evans served as an active member, assisted largely to justify the conclusions arrived at by men of science generally, that prehistoric man was living in Britain and in France contemporaneously with the large extinct Mammalia, the Mammoth, the Machærodus, the Rhinoceros, Hippopotamus, Cave Lion, Bear, and Hyæna, and such now existing northern forms as the Reindeer, Musk Sheep, and the Asiatic Saiga Antelope.

Most valuable, among Mr. Evans' many services to science, has been his endeavour to tide over the gap between the Prehistoric and Historic periods of mankind, and to emphasize the importance of the Quaternary period in geology. He has also established for us a correct chronological succession of periods of time represented by the various discoveries of the implements and objects made by prehistoric man, which clearly indicate that gradual progress from the most barbaric savage whose weapons of stone were rudely chipped, and neither ground nor polished; until, as he advanced in intelligence and skill, we meet with a class of implements which after being fashioned by chipping have been ground or polished at their edges only, and again still further with those which are more or less ground or polished, not only at the edge, but over the entire surface.

The rudest forms of implements are classed as belonging to the "River drift Period," the Palæolithic age, and are associated with the Mammoth and the Tichorhine Rhinoceros. Following on these we have the men of the Reindeer and Cave Period, with implements rather better finished, and, as a hunter-people, largely using harpoons and arrowheads of bone skilfully carved. Later, in the Neolithic Period, we find the makers of polished stone weapons with ground edges. Even in the subsequent Bronze Period that valuable alloy was also accompanied by highly finished stone axes, many being perforated and made in graceful forms.[1]

[1] The discussion of the various discoveries relating to prehistoric times, and the antiquity of the human race and the evidence bearing upon it, will be found in a long series of admirable Presidential Addresses to the British Association, Ethnological Section, Liverpool, 1870; to the Geological Section, Dublin, 1878; to the Anthropological Section, Leeds, 1890; as President of the British Association, Toronto, 1897-98; in 1861 in a lecture to working men at the Southampton Meeting; in an address to the Watford Natural History Society, 8th February, 1877; and as President of the Geological Society, 19th February, 1875. For an account of the flint implements in the Drift, see *Archæologia*, 1860 and 1862. There is an admirable paper on Bone and Cave-deposits of the Reindeer Period in the Quart. Journ. Geol. Soc., 1864, p. 444 (abstract), and Reliquiæ Aquitanicæ, 1875, p. 161 seq., and the subject is fully treated in Sir John Evans's "Ancient Stone Implements, Weapons, and Ornaments of Great Britain," 8vo (1872, and 2nd edition, 1897).

On February 20th, 1880, the Council of the Geological Society conferred upon Mr. John Evans the Lyell Medal, "in recognition of his distinguished services to geological science, especially in the department of Post-Tertiary Geology." In presenting it, Dr. H. C. Sorby, the President, said: "I can well remember the time when there appeared to be an almost impassable gulf between antiquaries and geologists, but you and your fellow-workers have so completely bridged over the gulf that we now can scarcely say where archæology ends and geology begins, nor whether to rank or value you most as an antiquary or a geologist" (GEOL. MAG., 1880, p. 180).

The announcement in the *Annals and Magazine of Natural History* for April, 1862, of the discovery made by Dr. Haberlein, in the Lithographic Stone of Bavaria, of "a fossil reptile clothed in feathers," which Professor Wagner named *Griphornis longicaudatus*, attracted much attention. This was followed by a notice by Professor H. von Meyer a month later, giving an account of the same fossil and naming it *Archæopteryx lithographica*. The specimen was acquired for the British Museum in 1862, and Mr. John Evans was greatly interested in it as possibly affording evidence of a form intermediate between Birds and Reptiles. The suggested reptilian-like characters were based upon the free-clawed phalanges of the wings, and the long lizard-like tail, composed of 20 free unanchylosed vertebræ, but the head was wanting. Owen, in describing it, adhered to the fossil being a true bird by the fact that it was clothed in feathers and appeared to have the foot of a true perching bird, and he insisted that the feathers proved the existence of a *beak* for preening its plumage.

Mr. Evans drew attention to a rounded body which in the counterpart slab was represented by a hollow lined by a thin brown bony layer (apparently the cranial cavity). In order to elucidate this he proceeded to procure the heads of a very large number of wild birds, such as the Magpie, Rook, Crow, Gull, Jay, Woodcock, Snipe, etc. Casts were made by him of the brain cavities of these, and the skulls bisected so as to expose the cast of the upper surface of the two hemispheres of the brain and to show the hollow of the cranium. He also called attention to a small broken and detached jaw bearing five teeth upon its dentary border, resting on the same slab. Professor Owen refers to the first as "a concretionary nodule, which *may be*, as suggested by Mr. John Evans, part of the cranium with the cast of the brain of *Archæopteryx*" (Phil. Trans., 1863, p. 46). But he dismisses the jaw as a "premaxillary bone and impression of same, resembling that of a fish."

Mr. John Evans laid his case by letter with drawings before Professor Dr. Hermann von Meyer in 1863, who replied: "I hazard no opinion on the cast of the skull; much more important is the jaw." "Teeth of this sort I do not know in the Lithographic Stone. They are *not* like the teeth of Pterodactyles. The nearest likeness is to *Acrosaurus Frischmanni*, Meyer, a reptile from the Lithographic Stone of Bavaria." He goes on to compare the teeth with *Pleurosaurus Meyeri* and with *Geosaurus Soemmeringi*, Meyer, which he says are much longer, and ends by observing "From this it would appear that the jaw really belongs to *Archæopteryx*."

Mr. John Evans's paper on "A Cranium and Jaw in the Slab containing the *Archæopteryx*" was published in the *Natural History Review* for July, 1865, but it was not until 1884[1] that Dr. Dames described the second specimen of long-tailed *Archæopteryx* (obtained for the Berlin Museum), in which the head and neck of the bird are preserved with the jaws furnished with numerous pointed teeth, fully confirming Sir John Evans's observations on the *Archæopteryx* in the British Museum made twenty years earlier. Already in 1881 Evans had inspected the specimen in the Berlin Museum and reprinted the article of 1865 with some prefatory remarks on the peculiarities of the Berlin specimen.

Another subject which engaged Mr. John Evans's attention as early as 1866 was the consideration of a possible cause of climatal changes. We are all aware that great changes of climate have taken place in the northern hemisphere, and we have every reason to assume that corresponding changes have in all probability taken place in the southern hemisphere; also periods of glaciation may account for accession of cold, but it may be doubted if by any rearrangement of land surfaces or of warm currents, like the Gulf Stream flowing north, a sub-tropical, or a warm temperate climate even, could be forced up towards the Poles. Nevertheless, such a condition seems needed to explain the fossil vegetation in Tertiary times met with in Greenland, Arctic America, and Spitzbergen. Mr. Evans suggested that if the earth's crust were composed of solid material of equal density and thickness, and the interior were filled with fluid matter over which the shell could freely move, and the whole were in uniform rotation upon an axis, the hollow sphere being in perfect equilibrium, its axis and that of its fluid contents would perpetually coincide. If, however, the equilibrium of the shell or crust be destroyed by the addition of a mass of matter, midway between the pole and the equator, the centrifugal force of the mass of matter so added would gradually draw over the shell towards the equator; thus, though the whole sphere continued to revolve around its original axis, yet the position of the pole of the hollow shell would be changed by 45° and the whole surface would have shifted from its original position to the same extent. The axis of the hollow sphere would again coincide, and would continue to do so until a fresh disturbance took place. If instead of the addition of fresh matter a portion of the shell were removed, a reverse movement would result, and that part of the shell excavated would eventually find its way to the Pole. An ingenious model to exhibit this was shown before the Royal Society (March 15th, 1866); it illustrated the changes produced on a moving wheel by the alteration in the adjustment of the weights around its rim. The subject was ably discussed at the time and subsequently at the Geological Society on February 21st, 1877.[2]

In 1892 Sir John Evans gave evidence before the Royal Commission on Metropolitan Water Supply. He then put in a statement with

[1] See Geol. Mag., 1884, Professor Dames on *Archæopteryx*, pp. 418-424, Pl. XIV.

[2] Geol. Mag., 1866, pp. 171-174, 183-187; 1877, p. 219.

regard to the rain-gauges and the percolation gauges which had been started at Nash Mills in 1836 by his uncle John Dickinson, and had been in continuous operation under his own direction since 1853. Sir John Evans brought the subject before the Institution of Civil Engineers in 1885 in a lecture on "Physiography," one of a series, given by distinguished observers, on "The Theory and Practice of Hydro-mechanics."

In his evidence in 1892 he stated that the average percolation for thirty-seven years through 3 feet of soil, on which grass was allowed to grow, was 7·55 inches, and through 3 feet of chalk 10·71 inches; the yearly average rainfall being 27·42 inches. He felt it unsafe, however, to calculate on a certain supply of more than 4 inches of the rainfall, whether from the springs or streams of such a district as the Chalk of Hertfordshire, because many vegetable roots penetrate the earth to a far greater depth and absorb moisture, and in dry seasons moisture can be brought from a greater depth in Chalk by means of capillary attraction. Sir John Evans also dealt with the effect on the streams of pumping water from the Chalk.[1]

Sir John Evans has on several occasions acted as a guide to the Geologists' Association, having conducted or taken part in the conducting of excursions since 1875 to Watford, Tyler's Hill, Chesham, and Berkhamsted.

He has an extensive knowledge, not only of prehistoric archæology, but also of ancient, especially British gold coins, and of engraved gems. More than this, though he left school so early, he is a really good classical scholar, besides being well versed in at least three modern languages. Few men have shown more conspicuous ability in transacting the business of societies. His experience of life and affairs, as manager of an important commercial undertaking, as a county magistrate, as member or chairman of committees of different kinds, make him invaluable in any official position. He was three times a member of the Council of the Royal Society—on the last occasion for a period of twenty years as its Treasurer. In that office he rendered great service to the Society in bringing its financial affairs into a satisfactory condition, and his advice on the various and sometimes difficult questions brought year by year in increasing numbers before the Society was always of the highest value. In 1884, in consequence of the illness of Professor Huxley, P.R.S., he delivered the Anniversary Address. Of the Geological Society he was Secretary from 1866 to 1874, President from 1874 to 1876, and Foreign Secretary from 1895 to the present date, besides being a member of the Council and Vice-President on other occasions. Of Sir John Evans's long connection with the Society of Antiquaries and his communications to that body on subjects which have no bearing on geology this is not the place to speak. With regard to the Royal Numismatic Society, which he joined in 1849, it may be mentioned that he has been since 1860 one of the Editors of the *Numismatic Chronicle*, which is now completing its 47th volume. In 1878–9 he was President of the Anthropological Institute. In 1893 he was Chairman of the Society of Chemical

[1] See his second Presidential Address to the Geological Society (GEOL. MAG., 1876, pp. 185–186).

Industry, delivering an address at Liverpool, and in 1900 Chairman of the Society of Arts. For many years he has been President of the Paper Manufacturers' Association.

He received the honour of being created K.C.B. in 1892. His services to the County of Herts as Chairman of Quarter Sessions and of the County Council and in other capacities, were recognised in 1905 by the presentation of his portrait and of a magnificent silver-gilt cup. For seven years he was President of the Egypt Exploration Fund, and he has from its inception been Chairman of the Lawes Agricultural Trust Committee. His knowledge of affairs and of men, his courtesy, tact, and clearness of view, his happy gift of expression and facility in drafting a resolution, his readiness to yield on matters of minor importance and his firmness on those of principle, will make one so witty and yet so wise, so strong and yet so conciliatory, sorely missed when he disappears from the ranks of those who have worked for the good of science and learning.

Sir John Evans married, first, Harriet Ann, daughter of John Dickinson, F.R.S.; second, Frances, daughter of Joseph Phelps; third, Maria Millington, daughter of Charles C. Lathbury, Wimbledon, 1892. He has two sons and two daughters surviving. His eldest son, Arthur John Evans, D.Litt. Oxford, Hon. LL.D. Edin., Hon. Litt.D. Dublin, M.A., F.R.S., F.S.A., has been Keeper of the Ashmolean Museum, Oxford, since 1884, and is a Fellow of Brasenose College, Oxford; was born 1851. Sir John Evans celebrated his 84th birthday on the 17th November last, and was warmly congratulated upon the auspicious event by the Press and by a wide circle of friends and scientific colleagues.

His ardour in the pursuit of his favourite study of Geological Anthropology remains unabated. So lately as the 18th December last he communicated to the Geological Society of London an important paper on some recent discoveries of palæolithic implements on the southern borders of Bedfordshire and in the north-western part of Hertfordshire, obtained by Mr. Worthington Smith, of Dunstable. In addition to the discovery of a palæolithic floor at Caddington brickfield, at between 550 and 590 feet above sea-level, implements have since been found on the surface of the ground at 600 and 760 feet respectively; while a good ovate implement was found in thin, water-laid material, at 651 feet O.D. In Hertfordshire palæolithic implements have been found at Great Gaddesden, at a brickfield about 1½ mile north-east of Hemel Hempstead, and at Bedmont, 2 to 2¼ miles south-east of the last locality. The drifts which cap the hills in North-West Hertfordshire seem to be of very variable origin, and a great part of the material is derived from clay-deposits of Eocene age, but little remanié. It seems to Sir John that it is safest not to invoke river-action for the formation of the high-level deposits, which extend over a wide area and are in the main argillaceous and not gravelly or sandy in character, but to adopt Mr. Worthington Smith's view, that in early times lakes or marshes existed in these implementiferous spots, the borders of which were inhabited by Palæolithic Man. The evidence that he has brought forward as to the implements having, in some of the Caddington pits, been manufactured on the spot, most fully corroborates this view.

The meeting was a very large one, and the paper was cordially received and discussed by a great number of eminent geologists acquainted with the country and with palæolithic implements, of which a fine series was exhibited.

WORKS BY SIR JOHN EVANS, K.C.B., F.R.S.

1860. "Flint Implements in the Drift; being an account of their discovery on the Continent and in England": Archæologia, vol. xxxviii, p. 280, pp. 28, 2 pls.

1862. "Flint Implements in the Drift; being an account of further discoveries on the Continent and in England": Archæologia, vol. xxxix, p. 57, pp. 28, 4 pls.

1864. "The Coins of the Ancient Britons": arranged and described by J. E. and engraved by F. W. Fairholt. 8vo; pp. 424, 26 pls.; London. Supplement, 1890.

"On some Recent Discoveries of Flint Implements in Drift-deposits in Hants and Wilts": Quart. Journ. Geol. Soc., vol. xx, pp. 188–194; Phil. Mag., vol. xxvii, p. 544.

"On some Bone and Cave-deposits of the Reindeer Period in the South of France": Quart. Journ. Geol. Soc., vol. xx, p. 444; Phil. Mag., vol. xxviii, pp. 321–322; GEOL. MAG., p. 85; Reliq. Aquit. (1875), p. 161.

1865. "On portions of a Cranium and of a Jaw in the Slab containing the Fossil Remains of the *Archæopteryx*": Nat. Hist. Review, pp. 415–421. Reprinted 1881.

1866. "On some Flint-cores from the Indus, Upper Scinde": GEOL. MAG., Vol. III, pp. 433–435.

"On a possible Geological Cause of Changes in the Position of the Axis of the Earth's Crust" [1866]: Proc. Roy. Soc., vol. xv (1867), pp. 46–54; Amer. Journ. Sci., vol. xliii (1867), pp. 230–239; Phil. Mag., vol. xxxi, pp. 537–545; GEOL. MAG., Vol. III, pp. 171–174.

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Anniversary Address delivered at the Annual Meeting, 8th February, 1877, "Archæology and the Antiquity of Man": Trans. Watford Nat. Hist. Soc., vol. i, pp. 187–200.

1881. "The Ancient Bronze Implements, Weapons, and Ornaments of Great Britain and Ireland": 8vo; pp. xix, 509; London.

1882. "L'Age du Bronze" . . . Traduit de l'anglais par W. Battier . . . corrigé par l'auteur:, 8vo; pp. viii, 551; Paris.

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1885. "Physiography." Opening Lecture of a course on Hydrodynamics delivered before the Institute of Civil Engineers: Proc. Inst. C.E.

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1892. "Posy-rings," a Friday evening discourse at the Royal Institution . . . . 1892: 8vo; pp. 30; London.

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1899. "Il y a Quarante Ans": Assoc. Franc. Adv. Sci., pp. 296–298.

"The Antiquity of Man, with especial reference to the Stone Age in Egypt" [a presidential address delivered to the Birmingham and Midland Institute]: 8vo; pp. 1–15; London.

1900. "The Origin, Development, and Aims of our Scientific Societies": Address to Society of Arts.

1906. "On Formation of Pipes in Chalk": Quart. Journ. Geol. Soc., vol. lxii, p. 490.

"On a recent Palæolithic Discovery near Rickmansworth": Trans. Herts Nat. Hist. Soc., vol. xiii, pp. 65–66.

1907. "Some Recent Discoveries of Palæolithic Implements": Geol. Soc., Dec. 18th.

LIST OF HONOURS CONFERRED ON AND OFFICES HELD BY SIR JOHN EVANS, K.C.B.

1849. Member of the Numismatic Society, Secretary 1854–74, President 1874 till now; Medal in gold 1887; one of the Editors of the *Numismatic Chronicle* from 1860 onwards.

1852. Fellow of the Society of Antiquaries, President 1885–92.

1857. Fellow of the Geological Society, Secretary 1866–74, President 1874–76, Foreign Secretary.

1859. Associate of the Institution of Civil Engineers.

1861. Joined British Association. Presided over Ethnological Department, Liverpool, 1870; over Geological Section, Dublin, 1878; over Anthropological Section, Leeds, 1890; President, Toronto, 1897–8.

Joined Ethnological Society, subsequently Anthropological Society and Anthropological Institute; President 1877–9.

1864. Fellow Royal Society, Vice-President 1876, Treasurer 1878–98. Delivered Anniversary Address 1884 in absence of Professor Huxley.

1865. Elected to Athenæum Club under Rule 11.

Assisted in founding and President of the Watford Natural History Society (afterwards the Herts Natural History Society).

1900. Chairman of the Society of Arts.

1892. Created Knight Commander of the Bath (Civil Division).

DEGREES, ETC.

D.C.L. Oxford, 1877; LL.D. Dublin, 1878; Sc.D. Cambridge, 1890; D.C.L. Toronto, 1897; LL.D. Trinity College, Toronto, 1897.
Hon. Fellow, Brasenose College, Oxford, 1903.
Hon. Member Royal Irish Academy.
J.P. Herts, 1870; Deputy Lieutenant, 1876; Sheriff, 1881; Deputy-Chairman Quarter Sessions, St. Albans, 1887; Chairman, 1889; Deputy-Chairman Herts County Council, 1889–98; Chairman, 1898–1905.
Trustee of the British Museum since 1885.

FOREIGN HONOURS.

1851. Hon. Member Société royale de Luxembourg.
1859. Mem. corr. Soc. d'Emulation, Abbeville.
1865. Hon. Memb. Instituto di correspondenza archeologica di Roma.
1874. Corr. Memb. Berliner Gesellschaft für Anthropologie.
1877. For. Memb. Société d'Anthropologie de Paris.
1881. Hon. Memb. American Philosophical Society, Philadelphia.
Knight Commander of the Order of St. Thiago of Portugal.
1887. Correspondant de l'Institut (Acad. Inscr. and Belles Lettres) Prix de Numismatique, 1865.
1888. For. Hon. Memb. American Academy of Arts and Sciences.
1891. Memb. hon. de la Société Géologique de Belgique.
1897. Corr. Memb. Academy of Sciences of Bologna.
1905. Officer of the Order of St. Charles of Monaco.

II.—NOTES ON THE DRIFT AND UNDERLYING DEPOSITS AT NEWQUAY, CORNWALL.

By B. B. WOODWARD, F.L.S., F.G.S., etc.

(PLATES II AND III.)

IN the Summer of 1900 the present writer on a visit to Newquay casually observed a deposit containing land shells near the Lifeboat House by Towan Head. The description of the little section was included in a joint paper by Mr. A. S. Kennard and himself on the "Post-Pliocene Non-marine Mollusca of the South of England"[1] and fortunately assigned in error to the Pleistocene period.

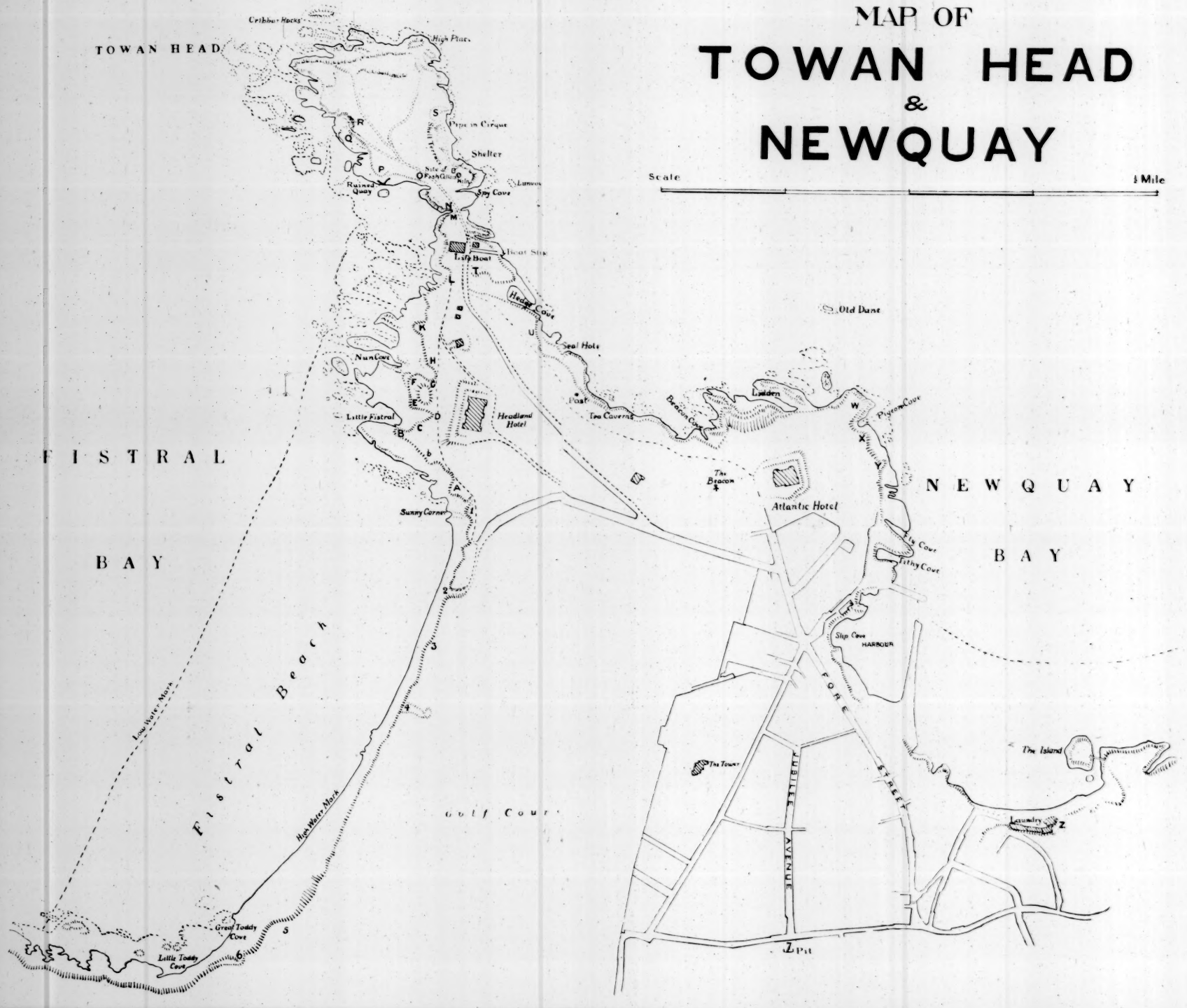
Fortunately, because the mistake elicited a very interesting and important communication on the series of deposits at that locality by Mr. S. Hazzledine Warren, with determinations of the shells and notes by Mr. A. S. Kennard.[2]

A holiday lately spent on the spot afforded the chance for making further observations, which supplement those of Mr. Warren in some respects, but differ from his in a few points, owing probably to some change in the sections in the interval. The list of mollusca has also been increased by the addition of several more species.

Opportunity was further taken of noting the sections of all the beds above the Killas, and since these seem largely to have been misunderstood, and vary under the destructive influence of Winter storms, it may be useful to place on record their present aspect.

[1] Proc. Geol. Assoc., vol. xvii (1901), p. 247.
[2] GEOL. MAG., 1903, pp. 19–25.

MAP OF TOWAN HEAD & NEWQUAY



The early literature on the subject has been so well summarised by Mr. W. A. E. Ussher in his far too little-known paper on the "Post-Tertiary Geology of Cornwall"[1] that further allusion to it is unnecessary.

The geological sequence of the beds in question is in reality very simple, but there has been so much slipping in the cliffs that it forms a veritable geological booby-trap for the casual visitant, or the hurried geological surveyor. The latter, to whom this class of deposit is caviare,[2] having under a misguided system so many square miles to cover in the day, cannot spare time for any but the most superficial glance as he sketches from the beach what really requires careful investigation to properly elucidate. On this account some very remarkable misreadings have found their way into print.

Briefly put, the sequence of the beds above the killas and their history is as follows:—

To begin with, at the commencement of their deposition, while the rocky headlands were much the same as they are to-day, the sea occupying the old Fistral Bay stood relatively higher and extended some distance over the site of the present golf links in the direction of the harbour—how far, in the absence of sections, it is impossible to say. On the denuded upturned edges of the killas in this tidal bay were laid down, first a pebbly beach full of boulders and then a thick deposit of marine sand exactly comparable to that occupying the present bay. This sand attained at the sides of the bay a thickness of as much as 20 feet, but shelved down to what was then the deepest point of the bay and is now the depression (miniature dry valley) in the golf links.

To this succeeded the period marked by the deposition of the well-known 'Head,' or remarkable clayey deposit full of angular fragments and occasional boulders of rock.

The exact time in the history of the bay when the recession of the sea took place is not clear, but there are indications that this event may have preceded the formation of the 'head,' the marine sands having in places obviously suffered previous denudation. At all events, the 'head' spread out over and partly filled up the trough of the old bay and quite probably extended partly up the flanks of the hills. This 'head' has frequently been described, and it seems pretty commonly agreed that it was due to minor local glacial conditions entailing a heavy snowfall and the formation of névé. The melting of this snow in warm Summers would release considerable volumes of water, which sinking through the underlying marine sands would erode in their indurated portions those remarkable vertical cylindrical pipes commented on and figured by Mr. Clement Reid.[3]

Whether, as suggested by Mr. Reid, this deposit will yield remains of Arctic plants or animals is problematical. No sign of life has as

[1] Geol. Mag., 1879, pp. 206–7.

[2] The terms for these beds in what may be styled the pre-glacial days of the Geological Survey seems to have been "Extraneous Rubbish" ("History of the Geological Society," p. 134).

[3] Geology of the Country near Newquay (Geol. Surv. Mem., Sheet 346), p. 67, pl. v.

yet been extracted from it, whereas in the succeeding epoch molluscan life at all events was abundant, while man occupied the area.

It is usual to speak of these overlying latest deposits as 'blown sand.' This, however, is inaccurate: when investigated they prove to contain a large amount of soil, and are in reality composed of hill-wash with a large admixture of calcareous sand blown up off the beach. Consequently they may more correctly be termed 'hill-wash-dunes.' Of true 'blown sand' dunes there are a few examples in the lower part of the links near the road down to the beach and possibly a few towards the centre of that ground where less hill-wash would be brought down.

This dune period is divisible into two stages. An earlier layer present in the vicinity of the Headland Hotel, which is characterised by a molluscan fauna of a more woodland facies than that of the later period, and probably connotes a time when the sea had not re-excavated the bay to anything like its present extent. It is in this lower layer that the chief human remains occur. The later and more predominant hill-wash-dunes that overlie this suggest by their fossil contents the gradual coming on of the present open heath-like conditions and the nearer vicinity of the sea.

The first observer to give the correct reading of the sequence of these beds was Dr. H. S. Boase,[1] who is at great pains to point out the two series of sands, one above and the other below the 'head,' and he corrects De la Beche's error of considering the lower series with its consolidated portions to be blown sand. Dr. Boase's paper is worthy of more attention than it appears to have received: even Mr. Ussher has failed to notice this portion of his paper.

Turning to the actual sections and taking Fistral Bay first, we find in the northern angle of the bay (1 on the map, Plate II), next the Headland Hotel, as all along the bay, 1–2 feet of hill-wash surface soil. Under this there is 4 or 5 feet of 'head' resting in turn on the indurated old marine sands that pass down into the old pebble beach at the base; these two last having a total of 10 feet to the killas, of which all along the bay about 10 feet is exposed.

Proceeding southwards, the old marine sands become less indurated, while the pebble beach is less pronounced. About 50 yards south from the first point there has manifestly been some erosion of the old marine deposits and a corresponding thickening of the 'head,' the section showing from 4 to 5 feet of 'head,' then a sand seam 5 feet (which has nothing to do with the indurated series, though it may have been derived from the destruction of beds thereof that lie higher up on the slopes of the hills), and another layer of 'head' 3 feet thick, beneath which there is a trace only of the old sand and beach. This spot appears to represent the lowest point in the tideway of the old bay.

When the road down to the beach (2) is reached the 'head' is found to be only some 6–8 feet, resting on about 5 feet of the old beach, which here consists of layers of sand and pebbles passing down into the coarse pebbly beach at the base. Judging from his

[1] Trans. Roy. Geol. Soc. Cornwall, vol. iv (1832), pp. 468–9.

description, this must have been the section described by S. R. Pattison,[1] and the spot whence he obtained the shells identified by Crouch to be "*Modiola vulgaris, Cytherea chione, Patella, Ostrea.*" It is, of course, impossible to pronounce definitely in the absence of the specimens themselves, but judging from what can be obtained on the spot to-day it seems more probable that the first two should read *Mytilus edulis* and *Venus verrucosa*.

By the path from the golf links to the beach (3) only about two feet of 'head' is to be seen resting on the old beach. The upper layers of the latter, which is altogether 5 feet in thickness, are far less pebbly than at the last section, while there is the usual coarse pebbly base.

Under the old lead-mine tip (4) the 'head' is very sandy and contains few of the characteristic angular fragments of rock, which come in again, however, a few yards further to the south, the old marine sands with pebble seams passing down into the bouldery base, while laterally they once more become indurated and stand out from the cliff face in miniature bluffs.

Still passing southward these indurated sands are seen to rise in places nearly as high as the top of the 'head,' while in others they appear to have been denuded, and the 'head' extends downwards till it attains as much as 10 feet in thickness.

Where the cliff rises towards the south end of the bay the 'head' is about 3 feet thick, while there is about 20 feet of indurated sand between it and the layer of coarse pebbles at the base.

In the southern angle of the bay, by the first path down (6), where the cliff is from 40 to 50 feet high, the indurated sands are last seen projecting out from among the talus about half-way up. Thence eastward along the East Pentire headland coastline no vestige of them was observed, the 'head,' as shown in the cliff lately scarped in the formation of a promenade, coming right down, full 30 feet in thickness, and resting at first on the old coarse pebble beach and afterwards on the killas itself.

Although all along the bay only about 2 feet of top stuff shows in the cliff face, there are plenty of hill-wash-dunes just inland containing abundance of shells belonging to the latest phase in their history. One of these (5), close to the edge of the cliffs near their highest point, has been cut into alongside the path and shows a section over 4 feet thick. An example of *Helix aspersa* occurred at 3 feet from the surface, and there were a few small fragments of *Mytilus*. A list of the shells obtained from this spot is given in the table at end. Nowhere were any traces observed of the older phase as in the more interesting sections close round the Headland Hotel, to which attention may now be directed.

Returning to the northern angle of the bay (A on the map), and proceeding westwards along the first promontory, the indurated sands of the old marine series are again observed, from 10 to 15 feet thick according to circumstances, since they rest on an irregular surface of killas to which, when the coarse pebbly base is wanting, they are

[1] Trans. Roy. Geol. Soc. Cornwall, vol. vii (1848), p. 50.

firmly adherent. At this point the vertical cylindrical piping begins to be noticeable. Over these sands there is 3 to 5 feet of 'head,' whose upper surface slopes westwards, and the western two-thirds of the promontory is capped by the remains of a big hill-wash-dune. The base of this is formed by the *Helix nemoralis* zone, as the earlier phase may be conveniently termed, and at first this is at the top of the cliff just under the surface soil.

Further on the later phase is represented.

At one point (*b*), viewed from the beach, it looks as if there were two layers of 'head' separated by a thick seam of sand. A close inspection, however, shows that the upper is a lenticular mass of remade 'head,' that had somehow been washed down from the higher ground behind and become incorporated in the upper part of the hill-wash-dune. The section reads as follows:—

		ft.	in.
1.	Top soil with land shells (where it rests on 2)	1	0
2.	Lenticular mass of remade 'head': at its thickest	1	6
3.	Sand with few land shells	2	0
4.	Shell seam with plentiful remains of *Mytilus*	0	2
5.	Sand with *Helix nemoralis*	1	0
6.	'Head.'		

Nearer the head of the promontory (B on map) the section is:—

		ft.	in.
1.	Sand with land shells	4	0
2.	Seam of numerous land shells	0	6
3.	Sand with few land shells thinning out eastwards and disappearing	0	9
4.	Seam of land shells with *Mytilus*...	0	4
5.	Sand with *Helix nemoralis*	1	6
6.	'Head.'		

More examples of *Littorina obtusata* were obtained from the upper sands here than at any other spot on the headland.

The end of the promontory itself is much stepped by slipping and weathering, the exposed margins of the hill-wash-dune bearing no relation to the mass of it that lies behind on the promontory itself.

Turning round the northern face and going towards the steps at C, the cut-away edge of a dune gives some 4 feet of sand with land shells, that is reduced to 2 feet at the steps. In neither spot, however, were traces of the *Helix nemoralis* zone observable.

At the head of the little cove, however, where the public path comes near the edge at D (see also Fig. 1), a little section of about a foot or so by the side of the path, where a dune is just cut into, shows masses of broken slate mixed at one point with sand and containing *Helix nemoralis* and other shells (see table at end).

Turning westwards again along the northern side of the cove, the 'head' is found at the top of the section, and just behind, inland, there is a large dune. Seawards the top of the 'head' slopes down again slightly, and the *Helix nemoralis* zone comes on with 1 foot or 1 ft. 6 in. of upper sands over it at the corner, E.

The next small piece of cliff is practically parallel with the sea front and about 50 yards in length. It affords almost, if not quite, the most interesting section in the district (Fig. 1). A big hill-wash-dune has been cut into, the highest point of which is towards the northern end (F), and the section is better read from north to south.

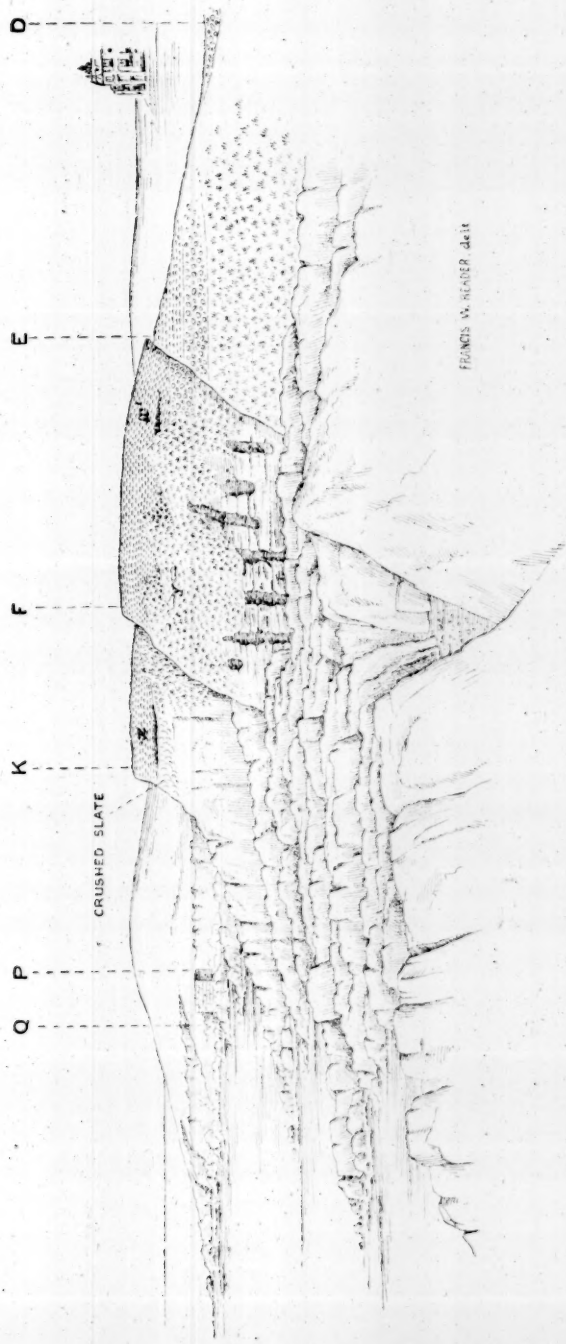


FIG. 1.—Diagrammatic view, from the point B on the Map, looking northwards, and showing the positions of the two prehistoric cooking sites (*e*, *f*) and the tubular masses of Indurated Sand in the *Helix aspersa* zone at *g*, etc. The capital letters correspond to those on the Map, Plate II.

At the point F, then, helped by the return section shown between F and G, we find:—

		ft.	in.
1.	Very sandy top layer with land shells, resting on a thin seam of broken slates	1	0
2.	Darker sand (? peaty) with land shells	2	9
3.	Seam of land shells with some *Mytilus*	0	3
4.	Lighter sand with fewer shells	1	6
5.	*Mytilus* layer overlying a seam with land shells passing down into 6	0	6
6.	Sand with few shells, the basal portion being the *Helix nemoralis* zone	3	0

This last is obscured at the point F by talus. Projecting from the talus in several places for the first few yards southward of F is a sort of ledge (*y*, Fig. 1), which at a distance looks as if it were the top of the 'head.' Close inspection, however, shows that this layer consists of tabular masses of the indurated sands placed side by side and resting on the true *Helix nemoralis* zone, which is here of a reddish ochreous colour. Specimens of *Helix nemoralis* and *Pomatias elegans* were found beneath these sandstone masses, which are thus separated by the thickness of the *Helix nemoralis* zone and the whole of the 'head' from the parent rock. In view of the presence of other indications close by, and presently to be mentioned, of the existence of man on the spot at this period, one is constrained to believe that these tabular masses were carried up by man and arranged to form a sort of platform as flooring for a hut or some other purpose. A boulder about the size of a man's head also lay there and appeared to have been similarly carried up from the beach.

A few yards from F another slip obscures the section, and passing it it is seen that the lower *Mytilus* band has split into two, and so continues till at a point about midway in the length of the section the following reading was taken:—

		ft.	in.
1.	Top soil and sand with land shells	2	0
2.	Seam of numerous land shells and *Mytilus*	0	1
3.	Sand with land shells	1	3
4.	Thick seam of *Mytilus* shells	0	2
5.	Sand with land shells	0	9
6.	Seam of *Mytilus* with few land shells	0	1
7.	Sand with land shells, depth not seen.		

A few feet to the south, while the surface trends downward, the *Mytilus* bands rise in the dune, and the uppermost one dies out near the top, while the second and third nearly reach to it, re-unite, and then dip down again as they pass to the south. At this point the section is again obscured by grass-covered talus, and directly past this there is a most interesting section:—

		ft.	in.
1.	Sand with land shells	5	0
2.	*Mytilus* seam with *Patella* and land shells	0	3
3.	Seam of sand with few shells	0	6
4.	Blackened sand with charcoal and *Mytilus* shells	0	4
5.	Stones arranged to form a hearth	0	2
6.	More blackened sand and charcoal	0	3
7.	Broken slates arranged to form a rough hearth	0	3
8.	Seam of *Mytilus* shells		
9.	Sand with land shells (*Helix nemoralis* zone)	2	0
10.	'Head.'		

The head gives a clearer view of the miniature arch.

Layers 4 to 8 (*x'* in Fig. 1) form the second of the two true kitchen middens mentioned by Mr. Warren. How far it extends northward could not be determined, since it passed behind the grass-covered talus slope. It appears to occupy a slight depression in the surface of the head. The discovery of a regular hearth is of interest, while the state of preservation of the whole is remarkable, the fragments of charcoal being as fresh as if newly burned. Besides *Mytilus*, shells of *Glycimeris* [= *Pectunculus*], *Patella*, and *Purpura* were found in it with a single burnt *Helix nemoralis* and three or four *Helicella barbara*. The latter must have been accidentally introduced among the embers, for they could not have served as articles of diet.

The two *Mytilus* layers of the kitchen midden speedily unite southwards, and at the point E blend with the upper layer (No. 2 of the section).

As Mr. Warren notes, the dune sands appear in places here to pass down into the 'head,' but this is probably a false rather than a true junction.

The return section from F to G into the next miniature cove to the north is practically the same as at the point F.

At G there is an easy way down to the beach, and at the foot of the descent the indurated sands are well seen, not only in the cliff, capped by the 'head,' but also in masses on the foreshore. These last are apparently the subject of Mr. Reid's plate v in his Survey Memoir on the Newquay district. They must, however, have suffered considerable further denudation since he photographed them, for he could not have failed to see and record the interesting miniature natural arch shown in the accompanying view most kindly taken for me by the Rev. A. E. Oldfield (Plate III). The illustration shows the old marine platform of killas with its boulder-strewn surface, and the way in which the old marine sands, when there is no coarse pebble bed at the base, fit in between and around the boulders and are firmly cemented to them, the layers preserving their horizontality everywhere as only water-deposited strata can do. Some of the curious vertical pipes in the indurated sands, partly cut through, are also conspicuous in the mass in front of the cliff.

Round the rest of the cove the 'head' comes nearly to the top of the cliff, and no dune deposits worth recording are seen till the northern point K is reached. Here the killas rises at the point to 2 ft. 6 in. from the surface, and is much broken and crushed at the top (see Fig. 1). From the point eastwards its surface is slightly depressed, and a little further on the 'head,' almost wanting at the very point, comes on and rises to about two feet from the surface.

The hill-wash-dune that caps the point gives at its thickest the following section:—

		ft.	in.
1.	Top soil with land shells, resting on a seam of broken slates ..	1	0
2.	Sand with a seam of pebbles at the base	0	9
3.	Sand	0	8
4.	Sand with land shells	0	6
5.	Sand	1	0
6.	Layer of closely packed *Mytilus* shells with fragments of slate	0	2
7.	Sand	0	6
8.	Masses of charred *Mytilus* shells, burnt earth, charcoal, and burnt stones (*x* in Fig. 1)	0	6
9.	Traces of 'head,' resting on killas.		

Layer No. 6 corresponds to the lower *Mytilus* band in the sections F to G and again at L. It is the upper kitchen midden of Mr. Warren, and contains some stones that appear to show the action of fire, but no burnt earth. Land shells occur plentifully just above, in, and immediately below it.

Both this band and No. 8 are limited in extent, covering about 9 feet.

The latter much resembles the true kitchen midden at E, only no trace of a regular hearth is seen, and though quite as black when first dug out its contents, except the charcoal, dry paler. Besides *Mytilus* it yielded shells of *Patella* and *Purpura lapillus*, but no traces of land molluscs.

It is rather remarkable that no mention of these two interesting cooking sites is made in the Geological Survey Memoir, although Mr. Warren pointed out their existence three years before that work appeared. Judging, however, from the scant notice of Mr. Warren's paper, obviously inserted after the memoir had been written, the compiler not only was unacquainted with it at the time he visited the spot, but did not even make himself properly acquainted with it afterwards.

(*To be concluded in our February Number.*)

III.—The Sudbury Nickel-Ores.

By Professor A. P. Coleman, of the University of Toronto.

IN Professor Gregory's interesting presidential address contained in your journal for October, there is a reference to the origin of the Sudbury ores, in which he expresses the opinion that they were deposited from solution long after the first consolidation of the rocks with which they are associated. As the Sudbury ore deposits are perhaps the best examples in the world of the magmatic segregation of sulphide ores it seems a pity that the weight of Professor Gregory's authority should be given against the correct view. Probably he has not read the reports on the region by Dr. Barlow and myself in which incontrovertible proof of the magmatic origin of these ores has recently been given.[1] In the report prepared by myself it is shown that all the ore bodies are found at the lower edge of a laccolithic sheet of norite, blending upwards into micropegmatite, or on dike-like projections from this sheet. The laccolithic sheet is 37 miles long, 17 miles wide, and has dozens of ore bodies connected with its basic edge. The adjoining rock may be granite, gneiss, green schists, graywacke, etc., without affecting in any way the monotonous character of the ore. The ore bodies may contain fragments of the adjoining rocks and sometimes also of the norite, for some crushing and faulting has taken place; but everywhere the solid ore passes into pyrrhotite-norite, and then into norite spotted with blebs of ore. The sulphides have sharp boundaries against the adjoining rocks, but blend into the norite. The blebs of pyrrhotite may be found hundreds of yards from the ore bodies and completely enclosed in the norite with no fissure or

[1] Barlow, Ann. Rep. Geol. Surv. Canada, part H; Coleman, The Sudbury Nickel Field, Bur. Mines, Ontario, vol. xiv, part 3.

channel by which they could have reached that position by the aid of circulating water. The freshest norite of the region is found close to ore bodies and enclosing parts of the ore. Even so susceptible a mineral as hypersthene stands unchanged beside inclusions of pyrrhotite and chalcopyrite. In thin sections of the freshest specimens the sulphides are found embedded in original rock-forming minerals, such as hypersthene, augite, biotite, and even titaniferous magnetite, with no decomposition products between.

It is noteworthy that the ores, the heaviest parts of the original magma, everywhere occupy the lowest points in the eruptive sheet, bays projecting into the country rock, or long and sometimes interrupted offsets from the basic edge of the sheet, showing that gravity was an important segregative force. Even in the narrowest offsets, however, there is always some norite to show the connection with the main body of that rock.

Ore bodies never occur at a distance from the norite-micropegmatite sheet, and not one has been discovered elsewhere in northern Ontario after long and careful prospecting. That this eruptive mass was the source of the ore is evident, and it is equally evident that ore and rock reached their present position in a molten condition. It should be added, however, that a certain amount of later rearrangement of the sulphides has taken place, though there has not been sufficient water action to cause any banding or 'crustification' nor to introduce any appreciable amount of gangue minerals, such as quartz or calcite.

Practically every geologist who has visited the Sudbury ore deposits agrees with Dr. Barlow and myself as to their magmatic origin, and the only objections made to the theory have come from those who have studied specimens apart from their field relationships, or who have drawn inferences from the present arrangement of the ores as shown on polished surfaces. To determine the present arrangement of the ores throws very little light on their origin, for we are all agreed that a certain amount of solution and redeposition has gone on, especially in offset deposits, like the Copper Cliff mine. Any theory of original deposition of the ores from circulating waters must give a reason for the constant association of the ore with a single sheet of eruptive rock, for its presence only at the lowest points on its edge, for its blending upwards into the eruptive, and for the isolated blebs and masses enclosed in the fresh eruptive. All these relationships are easily explained by the magmatic theory, but very difficult to account for by any other.

IV.—Oceanic 'Deeps.'

By T. Mellard Reade, F.G.S., F.R.I.B.A., A.M.I.C.E.

ONE of the most characteristic features of the great oceans is the presence of what have been aptly termed 'deeps,' enormous depressions in the ocean bottoms. Having in my "Evolution of Earth Structure"[1] discussed their distribution and probable origin, I was

[1] Longmans, 1903.

naturally attracted by the notice in *Nature* of the surveys of the vessel "Edi" and the cable-ship "Stephan" during 1903 and 1905 in the western and south-western parts of the Pacific Ocean. Drs. G. Shott and P. Perlewitz, in a paper recently issued in the *Archiv der deutschen Seewarte*, taking into consideration previous work by U.S. ship "Hero" and of the German vessel "Planet," consider that these soundings throw a great deal of new light on the configuration of the sea bottom in those regions. They state that the troughs forming the deeps are usually about 10 miles wide, excepting the Guam deep, which is as much as 20 across. The most interesting statement to me is that in their opinion the troughs are the result of subsidence occurring on an enormous scale along lines of fracture, and that it is probable the *disturbances which produced these structures are comparatively recent.*

In p. 316, "Evolution of Earth Structure," I have said that the 'deeps' in "my view are produced by a *sagging* of the earth's crust similar to that which originated the Mediterranean basin," and further, "They may not be very old and necessarily more lasting than the deep basins in continental land such as the Black Sea and Lake Baikal."

It is pleasant to find that these later investigations by practical men tend to confirm my views and lead independently to similar conclusions, especially as the explanation involves the origin of other features of the sea bottom and the vexed question of the permanence of the larger features of the oceanic areas.

The narrowness of the troughs, if the figures are reliable, is striking, and points to vertical subsidence rather than lateral pressure. The subsidence in so narrow an area would doubtless be accompanied by fracture, but whether it is so or not we may legitimately infer, as I have done, that the originating cause is a local shrinkage of the magma under and beyond the area of the trough and deep down in or below the lithosphere.

The attainment of a reliable knowledge of the configuration of the ocean bed can only be of slow growth. Thanks largely to telegraph cable requirements, we have been adding to the facts in a fairly liberal manner of late years. Let us hope that the good work will continue notwithstanding the wireless phase of electrical development.

V.—A Revision of some Carboniferous Corals.[1]

By R. G. Carruthers, of the Geological Survey.

Introduction.

More than sixty years have now elapsed since the publication of the classical monograph of MM. Milne-Edwards and Jules Haime, "Les Polypes Fossiles des Terrains Palæozoïques." It can only be expected that many of the original descriptions of species in that work have for long been in need of amplification and revision. This applies with added force to the corals of the Carboniferous Limestone, in view of the impetus given to the palæontological study

[1] Communicated by permission of the Director of the Geological Survey of Great Britain.

of that formation, by the vigorous revival of zonal work witnessed in the last few years. Those species in most urgent need of revision belong to the lower, or Tournaisian division of the Limestone, since their satisfactory determination affords a basis for evolutionary studies on the succeeding faunas, and an attempt is here made to deal with a few of these forms.

The great French actinologists were compelled, in the absence of opportunities for slicing and microscopic investigation, to confine their attention to the external characters of their specimens, assisted occasionally by such rough vertical sections as could be obtained by fracture. This also was the case in what appears to be the only authoritative re-description of their species, published in 1870 by M. de Koninck, in his well-known volume entitled "Nouvelles Recherches sur les Animaux Fossiles du Terrain Carbonifère de la Belgique." Indeed, in the introduction to that work, M. de Koninck expresses regret at his inability to take advantage of the newer methods of research then being inaugurated. The older authors were not enabled, therefore, to completely define their species; for obviously the internal, as well as the external, structures must be determined before an adequate idea of the nature and relationships of these corals can be gained. Indeed, of the two, the internal structures are the more important, since, until they are known, the meaning and value of the chief external feature, the calyx, cannot be duly appreciated.

For the elucidation of these internal structures, great use has been made, in the present investigation, of serial transverse sections. Such treatment is entirely necessary, if reliable conceptions on these points are to be gained; by this means the progressive changes occurring during the growth of the coral are ascertained, specific differences are more correctly gauged, and, most important of all, the phylogenetic nature of various structures realised. It is true that the exigencies of space can rarely permit of such sections being illustrated in their entirety; that is, indeed, the case in the present instance, but the results obtained can, at any rate, be embodied in the text.

For a re-description of species to be of any value, it is evident that if paratypes are not available (i.e. examples named by the authors themselves), then, at any rate, the specimens used should resemble the originals in nature and preservation as closely as possible, and should be derived from the same locality (i.e. they should be topotypes); these conditions are fulfilled in the present case.

The holotypes of the species to be immediately described were collected from Tournai and sent by de Koninck [1] to Milne-Edwards and Haime for description in their "Polypes Fossiles." In his own work (the "Nouvelles Recherches"), published thirty years later, de Koninck dealt with similar material from this locality, whence also the specimens on which the present account is based (the majority forming the Piret Collection at the British Museum) have also been derived. These corals are silicified; the exquisite preservation of most of their calices resembles that of recent corals far more than those of Palæozoic age.

[1] With the exception of Michelin's *Caninia cornucopiæ* and *Caninia cornu-bovis*, which, however, also came from Tournai.

The corals in the Piret Collection were first of all compared with those in the Musée Royale d'Histoire Naturelle at Brussels, to ensure their identity with de Koninck's figured specimens. A certain number were then cut, the transverse sections serially and at right angles to the axis of the coral, the vertical sections mostly down the centre of the cardinal fossula, a few also being cut in a vertical plane, between the fossular depressions.

Both internal and external characters of the various species being then known, it was possible to recognise and examine further examples in other collections, and make some notes on variation and distribution. These latter observations, however, cannot pretend to have any great value or completeness. Very much more work requires to be done before the zonal value of these small corals can be ascertained. The evidence at present available is so scanty, and the districts that have been thoroughly searched are so few, that it must be some time before definite conclusions on this point can be stated. Some general observation on the results so far attained will be found at the conclusion of the paper.

My indebtedness to many sources of information and assistance is great. First of all, my sincere thanks are due to the authorities at the British Museum (Natural History) for permission to examine and cut the very beautiful corals in the Piret Collection, and to the Geological Survey for facilities in the investigation; without such aid this work could not have been undertaken. I also wish to thank MM. Dupont and Rutot, of the Musée Royale d'Histoire Naturelle, Brussels, for their courtesy in allowing me to examine the collections there preserved.

It is hardly possible to adequately acknowledge the kindness of Dr. A. Vaughan in allowing me to make the freest use of his extensive collections from the Bristol district, for a constant supply of fresh material, and for the most generous and ungrudging assistance throughout. I am also indebted to Dr. Matley and Dr. Vaughan for material from the Rush area (co. Dublin), and similarly to Professor E. J. Garwood, and to the members of the Yorkshire Geological Society, for material collected in the Arnside and Colne–Clitheroe districts respectively. Finally, I wish to sincerely thank the Trustees of the Sladen Fund for a grant in furtherance of this work, without which the accompanying illustrations could not have been so numerous or complete.

Septal Formation and Terminology.

Before proceeding to the description of the species, it may be of assistance to the general reader that attention should here be drawn to the peculiar mode of septal formation, so characteristic of Rugose corals, since an acquaintance with the facts concerned explains many difficulties and apparent anomalies met with during an examination of these corals, especially with regard to the fossulæ.

As it was not till 1870 that Kunth[1] first established his law of growth, many years after the appearance of MM. Milne-Edwards and

[1] Zeit. Deut. Geol. Ges., vol. xxi (1869).

Haime's publications, and as these latter still remain to many English readers the chief work on Palæozoic corals, it must be said that, although found in the larger palæontological textbooks, Kunth's work has not, perhaps, received in this country the attention it deserves. According to this law, the insertion of new septa in a Rugose coral takes place at three points in the circumference of the corallum, approximately 80° apart, the chief of these being at the *cardinal septum*, with the remaining two points on each side at the *alar septa*. New septa are successively added on each side of the cardinal septum, the youngest being always next to that septum. On one side only of each of the two alar septa new septa are also added, the youngest always next to those septa, on the side remote from the cardinal septum. Since these young septa are necessarily short, there is consequently, in transverse sections, a break in the grouping of the septa at each of these three points. These breaks form the *fossulæ*, the largest being naturally at the cardinal septum; this is called the *cardinal fossula*, or more simply '*the fossula*' The other two breaks, comparatively inconspicuous, are similarly referred to as the '*alar fossulæ*.' Occasionally a fourth fossula is developed immediately opposite the cardinal septum, and is called, from the primary septum dividing it, the *counter fossula*. No new septa are ever developed here, although the minor septa flanking the counter septum are occasionally more elongated than the others. These fossulæ are further marked by depressions of the tabulæ, varying in degree in different specimens.

The development of new septa according to Kunth's law may also be seen on the exterior of any rugose coral with good longitudinal ribbing, since each alternate groove corresponds to the position of a major septum; in any case, the arrangement can be seen on removing the epitheca by acid or filing, so as to display the septa within.

Fig. 1.

Fig. 2.

Fig. 1, Diagram A.—Transverse section of *Zaphrentis omaliusi*. Primary septa: H, cardinal septum; G, counter septum; A, A, alar septa; L, L, counter-lateral septa. a–c, the remaining major septa are lettered in the order of their formation. The minor septa are indicated by the ridges at the bases of the interseptal chambers. F, cardinal fossula; A–F, A–F, alar fossulæ; C–F, counter fossula.

Fig. 2, Diagram B.—Tabula of *Z. omaliusi*, represented by contours (after Vaughan). The deep depression is at the cardinal fossula, the three smaller ones at the alar and counter fossulæ. (See *infra*, p. 26.)

A diagram, Fig. 1, is appended as a key to the terminology used in this paper. In this connection the work of Kunth is followed, with two exceptions. The first, not of any importance for our present purpose, is the recognition of two more primary septa (the *counter-lateral* septa) in addition to the four enumerated by the German author. The second point concerns us more nearly. Previously most figures of the calyx and of cross-sections of rugose corals were so arranged that the cardinal fossula, if it occurred on the convex side of curvature of the coral, was shown on the upper side of the figure; if, on the other hand, the cardinal fossula occurred on the concave side of the coral, it was shown on the lower side of the figure. In the illustrations accompanying the present paper the cardinal fossula is in all cases shown on the upper side of the figure, since it is believed that recent work [1] enables us to extend to rugose corals the orientation adopted by common consent for other Anthozoa.

The terms 'major' and 'minor' septa are here used instead of the commoner terms 'primary' and 'secondary.' Since only the first six septa to be developed can properly be regarded as primary, the small intermediate septa should, if the common nomenclature be retained, be called tertiary septa, as has indeed been sometimes done. To avoid any confusion, it seems better to adopt some non-committal terms for the long septa and their intermediates, and therefore the terms 'major' and 'minor' septa are here used.

Genus ZAPHRENTIS, Rafinesque & Clifford.

Corallum simple, turbinate, conical or cylindro-conical, usually more or less curved. *Major septa* well developed, reaching quite, or very nearly, to the centre of the corallum. *Minor septa* may or may not be present; they are usually short. No columella is developed.

The conspicuous *cardinal fossula* is variable in position, and is completely enclosed and surrounded by septa, which fold round and form its walls. The *tabulæ*, though variable in character, are always a prominent feature, and are in direct connection with the wall; convex vesicles may arise on their upper surfaces, especially towards the circumference of the corallum; but these never assume a vertical alignment, and consequently in no case is there any trace of an external dissepimental zone of the nature of that found in *Campophyllum* and similar genera.

The above definition of the genus *Zaphrentis* is largely taken from that given by Messrs. Nicholson & Thomson (Ann. & Mag. Nat. Hist., ser. IV, vol. XVI, 1875, p. 426). In that article the nature of the cardinal fossula is for the first time regarded as "a character of primary importance in the definition of the genus." A restriction of this kind is necessary if the genus is not to attain unwieldy proportions, and although the above definition does not pretend to be founded on the specimens from which the original diagnosis was prepared, it undoubtedly represents the genus as understood at the present time. I have been unable to gather from the original description of MM. Rafinesque and Clifford any clear idea as to the nature of their specimens, and for the present, therefore, have retained the conventional definition in common use.

[1] Ann. & Mag. Nat. Hist., ser. VII, vol. XVIII (1906), p. 362.

ZAPHRENTIS OMALIUSI, M.-Ed. & H. (Plate IV, Figs. 1–4.)[1]

1851. *Zaphrentis omaliusi*, M.-Edwards & Haime: Pol. Foss. d. Terr. Pal., p. 337, pl. v, figs. 3, 3*a*.
1860. ,, ,, M.-Edwards: Hist. Nat. d. Corall., t. iii, p. 344.
1861. ,, ,, de Fromentel: Int. à l'et. polyp. foss., p. 289.
1872. ,, ,, de Koninck: Nouv. Recher. sur Anim. Foss. d. Terr. Carb. d. l. Belg., p. 94, pl. ix, figs. 4, 4*a*.
Hadrophyllum Edwardsianum, ibid., p. 52, pl. iv, figs. 2, 2*a*.
1905. *Zaphrentis* aff. *Phillipsi* (pars); Vaughan: Q.J.G.S., vol. lxi, p. 269, pl. xxii, figs. 2–*c*.

EXTERNAL CHARACTERS.

Corallum gently curved and conical, in the adult portion much less so, sometimes becoming almost cylindrical. There is longitudinal ribbing on the epitheca, more strongly marked towards the tip of the coral; round the calyx this may be supplemented by fine annular striations (Pl. IV, Fig. 2). Slight constrictions of growth are present, but 'rejuvenescence,' in the sense of an interruption in the continuity of the epitheca, never occurs. Excellent figures are given both by Milne-Edwards & Haime and by de Koninck.

Calyx deep, with abruptly descending sides. In young specimens a quadrate division of the septa within is well seen, four fossulæ being visible (*Hadrophyllum Edwardsianum*, de Kon.), but in the adult the septa usually have a very radial arrangement, with only one break, due to the shortness of the cardinal septum. Frequently, however, both cardinal and counter fossulæ are visible even in the adult; the former always lies on the convex side of curvature of the corallum. A good figure is given by Milne-Edwards & Haime. That of de Koninck is poor in perspective.

The *major septa* are strong, reaching to the centre of the calicinal floor, where they are slightly flexuous, thickened, and fused together, though still distinct from each other. They taper quite gradually up to the rim of the calyx.

The *minor septa* are entirely rudimentary, only appearing as low ridges between the thickened bases of the major septa.

Average dimensions.

Height of an adult specimen, 2–3 cm.; diameter of calicinal rim, 1·2–1·5 cm.; depth of calyx, 1–1·3 cm.

INTERNAL CHARACTERS.

(a) *Transverse Sections.*—The disposition of the *major septa* is far more readily seen in cross sections than in the calyx. They are seen to characteristically possess a curvature concave to the cardinal fossula. In sections across the adult portions of a corallum this curvature is sometimes not so marked, and occasionally a certain number of the septa may even be bent in the opposite direction for a portion of their length (Pl. IV, Fig. 4). The lobing and close interfusion of their inner ends gives rise to a dense mass in the centre of the section. This feature is not constant, however; examples may be found where the septal ends are not thickened and only join in the very centre of the coral.

The rudimentary *minor septa* only appear in sections across the

[1] Plates IV and V will appear in February.

adult portions of a corallum; they are never well developed, and are often barely perceptible.

The *cardinal fossula* is very generally a marked feature. Always completely surrounded by the major septa, in the lower part of the coral, it is broad and expanded at the inner end, but has a tendency to narrow higher up in the corallum, and though in typical examples a slight expansion of the central part is retained up to the floor of the calyx (Pl. IV, Figs. 1 and 4), continuous narrowing usually sets in beyond that point. The cardinal septum completely divides this fossula almost to the floor of the calyx, but latterly becomes much thinner than its neighbours. In extent the cardinal fossula never seems to reach beyond the centre of the coral, and usually falls short of it, often to a considerable degree; it would appear that sections cut across the more strongly curved parts of the coral show a short, broad fossula, and *vice versâ*.

A common and remarkable feature is the development of a *counter fossula* through a slight enlargement of the two interseptal chambers on each side of the counter septum. This character is almost always present in some degree in the young stage of growth of a normal example of the species (Pl. IV, Figs. 1*a* and 4*a*), and is often persistent throughout. This counter fossula is proportionately longer than the cardinal fossula, but, unlike the latter, of course never shows any appearance of young septa at its base. The counter septum may be either longer or shorter than its neighbours; when longer it is usually more markedly lobed at its inner end, thus approaching the distinctive character of the genus *Lophophyllum* (Pl. IV, Fig. 1*a*).

There is a tendency for the septa in each of the four quadrants to fuse together at their inner ends, the fused ends meeting in the centre of the coral. From this tendency arises the prominence of the fossulæ.

Dr. Vaughan's best figure is 2*e* (see Q.J.G.S., 1905, p. 269, pl. xxii).

(b) *Vertical Sections.*—The arched *tabulæ*, with their convex upper surfaces, are of an essentially simple type. They lie from 1 to 2 mm. apart, having depressions at each of the fossulæ, the extent of these depressions varying with the degree of development of the fossulæ. This being the case, the appearance of the tabulæ varies according to the direction of the section. Consequently, their nature is more clearly shown, not by the usual vertical section, but by a contoured figure of one of their number, as has been done by Dr. Vaughan, with whose kind permission the accompanying text-figure is reproduced. (See *ante*, p. 23, Fig. 2.)

Localities.

Millstone Grit: Greenfoot Quarry, near Glenboig, Lanarkshire (rare).

Upper (?) Visean: Hollins Delf, and other quarries near Colne; Horrocksford Quarry, near Clitheroe (D?).

Tournaisian: Big Weston Wood Quarry, Portishead, near Bristol, Clevedon, Failand, Woodspring (Weston), and other localities in the Z_2 subzone of the South-Western Province; Burrington, near Bristol (Z_1 subzone, rare); Rush Slates, co. Dublin (especially R 4 *a*, the position of which is given in Q.J.G.S., 1906, p. 276, fig. 1).

Remarks.

Under the name of *Hadrophyllum Edwardsianum*, de Koninck described (Nouv. Recher., p. 52, pl. iv, figs. 2, 2*a*), in my opinion, a young specimen of *Z. omaliusi*. He carefully described the strongly quadrate arrangement of the septa in the calyx, and the development of a counter fossula (on account of the latter character he referred the specimen to the genus *Hadrophyllum*), features which are seen to be characteristic of the young stages of growth of *Z. omaliusi*, though obscured in adult calices, and I have no hesitation in referring the specimen to that species. An examination of his figured specimen showed that it was much weathered; to this fact the unusual depth of the epithecal ribbing is due, as also the presence of a small median groove down the centre of each of the ribs, a fact to which de Koninck drew attention in his description. This latter character is not, however, of any specific value, but may be found in any much weathered Zaphrentid corals.

Z. omaliusi can, as a rule, be readily separated from other Zaphrentids. *Z. phillipsi*, M.-Ed. & H., has a certain resemblance, but according to the authors' account possesses very thin major septa, with a curvature (according to the figure in the "British Fossil Corals," pl. xxxiv, fig. 2*b*) convex, instead of concave, to the large fossula, which also has a long dividing septum in the calyx. Radical differences are also shown in the epitheca, which in *Z. phillipsi* does not seem to have longitudinal ribbing, and above all is frequently so affected by rejuvenescence as to have its continuity interrupted (see Polyp. Foss. d. Terr. Pal., pl. v, fig. 1). The differences from *Z. delanouei* will be referred to presently when dealing with that species.

Some resemblance to *Z. omaliusi* is occasionally displayed in the calyx of a young specimen of *Caninia cornucopiæ*, Mich. (*non* M.-Ed. & H.). But besides other differences the fossula in this latter species is deeper and longer, and in transverse sections is seen to be of a totally different character, being open at its inner end with the flanking septa usually disconnected, while in transverse sections the septa in the two cardinal quadrants are always affected by accessory thickening, a feature never seen in *L. omaliusi*.

With the exception of the two varieties to be immediately described the nearest corals to *Z. omaliusi* seem to be Densiphyllids, especially *D. charlestonensis*, Thom. These are, however, fundamentally distinguished by the possession of a most inconspicuous cardinal fossula, narrowing continuously to the centre of the coralium, and the major septa are almost purely radial in disposition, altogether lacking the characteristic curvature of those in *Z. omaliusi*.

Distribution.

The species seems quite local in its occurrence. Dr. Vaughan has kindly supplied an account of its distribution in the South-Western Province, but as it will be more convenient to insert these notes after the description of *Z. delanouei*, it is sufficient to mention that in that region *Z. omaliusi* attains its maximum in the Upper Tournaisian subzone Z_2, while it is again common in the Upper Tournaisian Rush

Slates of co. Dublin, correlated by Dr. Vaughan with subzone Z_2. But in other areas the species is found on different horizons. For instance, in the Colne–Clitheroe district it is found in limestones very probably of Upper Visean age, and is there rather common and quite typically developed. Again, in Scotland good examples seem very rare, but almost the only specimens yet obtained were found in the Millstone Grit near Glenboig, in a band of cement lying not far below the junction of the Upper and Lower Carboniferous floras. Nevertheless, no really typical examples have so far been found in the underlying and richly fossiliferous Lower Limestone group (Visean) and not one in the Tournaisian Cement Stones, where other small Zaphrentids are not uncommon in certain localities.

With the evidence at present before us the conclusion seems justifiable, therefore, that *Z. omaliusi* has an extensive vertical range, but may be locally confined to definite horizons.

Zaphrentis omaliusi, var. *ambigua*, var. nov. (Plate IV, Figs. 5 and 6.)

External Characters.

Dr. Vaughan has noticed the occurrence of this variety in the Rush Slates, and has drawn attention to the chief distinction from the Rush Zaphrentids (see Q.J.G.S., vol. lxii, 1906, p. 314, first paragraph on "variants of the Rush *Zaphrentis*").

Corallum similar in shape and external ornamentation to *Z. omaliusi*. The *calyx* is also similar to that seen in *Z. omaliusi*, save for the large size of the *counter fossula* lying on the concave side of curvature of the coral.

Internal Characters.

(a) *Transverse Sections.*—The chief characteristic of this variety is at once seen to lie in the *counter fossula*. This is developed to an extraordinary degree, more so than in any coral with which I am acquainted. Though initially small, for sections taken near the tip of the coral are essentially the same as similar ones in the normal species (compare Fig. 5*a* with Fig. 1*a*, Pl. IV), this counter fossula becomes increasingly apparent during the growth of the coral. The two septa forming the sides become more or less parallel, and in the final stages of growth an expansion occurs at the inner end, varying in degree with different specimens, and giving, in sections cut just under the calyx of an adult, a broad club-shaped outline to the counter fossula (Pl. IV, Fig. 6). The counter septum extends down the centre of this fossula throughout, and never becomes shortened to any appreciable extent, even in the calyx itself.

The *cardinal fossula*, on the other hand, is comparatively small and inconspicuous. The septa forming the sides also show a tendency to parallelism, though this appearance is naturally modified if the section happens to show the incoming of new septa (a feature never seen in the counter fossula).

In accordance with the extreme development of the counter fossula, the fusion of the septa of each of the four quadrants is very marked, and takes place further from the centre than in the normal species;

the fused ends meet in the centre of the coral. Apart from this fact the septa are certainly less flexuous and more uniformly curved than in the normal species.

A majority of the specimens I have examined also show decidedly thinner, and sometimes more closely packed, septa than in *Z. omaliusi*. This does not, however, seem at present to be a character of any great value. Exceptions certainly exist with strong septa fusing to a dense mass in the centre of the coral.

(b) *Vertical Sections.*—As in *Z. omaliusi*, though the depression of the tabulæ at the counter fossula is proportionately greater.

Localities.

Upper (?) Visean: Horrocksford Quarry, Clitheroe (common).
Tournaisian: Rush Slates (R 4 *a*, R 8 *a*, and especially R 6 *b*, for position of which see Q.J.G.S., vol. lxii (1906), p. 276, fig. 1).

Remarks.

The differentiation of this variety from *Z. omaliusi*, lying chiefly in the character of the cardinal and counter fossulæ, has been sufficiently dealt with in the foregoing description. In the possession of a prominent fossula, divided even in the calyx by a long septum, *Z. omaliusi*, var. *ambigua* resembles *Z. phillipsi*, as described by Milne-Edwards & Haime; but the latter has its prominent fossula on the convex instead of the concave side of the corallum, while the epithecal characters are very different. It also seems probable that the prominent fossula of *Z. phillipsi* is a cardinal rather than a counter fossula, and the same distinction immediately separates *Z. delanouei* from *Z. omaliusi*, var. *ambigua*, to which it otherwise has a great resemblance.

At both of the known localities the variety is found in association with normal examples of *Z. omaliusi*, and although the two are easily separable in typical examples they are united by intermediate forms whose reference to one or the other of the two corals is often no easy matter; and, indeed, it will be seen on comparing Figs. 1*a* and 5*a* on Pl. IV that the young stages of the species and its variety are essentially identical.

Distribution.

I am at present acquainted with only two localities for this curious variety. These seem, however, to lie on very different horizons. That in the Rush Slates has been correlated by Dr. Vaughan with the Upper Tournaisian subzone Z_2 of the South-Western Province. The other locality is Horrocksford Quarry, Clitheroe, where examples are abundant in certain shaly partings between beds of massive limestone containing a brachiopod fauna, indicating, according to Dr. Wheelton Hind, an Upper Visean horizon somewhere about the base of D or the top of S. These correlations, therefore, if correct, indicate a considerable vertical range for the coral.

Z. omaliusi, var. *densa*, var. nov. (Plate IV, Figs. 7 and 8.)

Shape, dimensions, and *epithecal characters* as in *Z. omaliusi*. The *calyx* also is very similar, save that the radial disposition of the septa

is more pronounced, the *cardinal fossula* only being denoted by the shortness of the cardinal septum.

In *transverse sections* the distinctive characters of the variety are well expressed. Here the curvature of the *major septa* is seen to be extremely even and regular throughout. The counter septum and its neighbours are prominent, being generally longer (Pl. IV, Figs. 7, 7*a*, though sometimes shorter (Pl. IV, Fig. 8) than the rest. Nevertheless, the interseptal chambers on each side of the counter septum rarely enlarge to form a counter fossula, though one, or both, may be so elongated as to reach the centre of the dense mass of fused septa lying in the centre of the corallum; this dense central area is of somewhat greater size than that observed in *Z. omaliusi*.

The inconspicuous *cardinal fossula* has a characteristic shape, narrowing inwardly, instead of slightly expanding as it does in the normal species. This occurs even in the young stages of growth, though sometimes masked by the insertion of young major septa.

Vertical sections show that the *tabulæ* are essentially of the same simple type as those in the normal species, but there is only one depression on their surfaces, corresponding to the single fossula usually present in this variety.

Localities.

Upper Visean: Crosshouse (Lower Limestone Group of Scotland) (D); Thornton and other quarries near Colne, Lancashire (D?); Warsaw Knoll, near Clitheroe (D?); middle and upper part of horizon Y, Burrington, Mendips.

Tournaisian: Big Weston Wood Quarry, Portishead, near Bristol (Z_2 subzone), very rare; coast at Malahide, co. Dublin (loc. 1), and Rush Slates, R 4 *a*, R 6 *a*, and R 8 *a*.

Remarks.

The points of difference between this variety and *Z. omaliusi* proper are certainly not great. Nevertheless, these differences are so constant and are so readily detected in a hand-specimen that in my opinion they clearly merit varietal distinction. The variety forms an intermediate link between *Z. omaliusi* and Densiphyllids of the type of *D. charlestonensis*, Thom.[1] When the septal curvature is but slightly developed it becomes a most difficult and often, so far as I can see, an impossible matter to separate the two corals. Such cases must, however, be expected in dealing with considerable assemblages of similar forms.

It is tempting to suppose that *Z. omaliusi*, *Z. omaliusi* var. *densa*, and *D. charlestonensis* represent so many stages in one line of evolution, more especially when it is remembered that in the Bristol district var. *densa* is chiefly found just above the maximum of *Z. omaliusi*, and *D. charlestonensis* occurs much higher up in D_2–D_3 of the neighbouring district of the Gower and Oystermouth, and is common on a probably similar horizon in Scotland and is again found in the shales overlying the Derbyshire Limestone. Nevertheless,

[1] J. Thomson, "Corals Carb. Syst. Scot."; Proc. Phil. Soc. Glasgow, p. 152, pl. vi, figs. 21, 22, etc. (1883).

when other areas are examined difficulties present themselves. For in the Colne–Clitheroe district, in limestones which at present we have every reason to regard as lying in the Upper Visean or D zone, we find *Z. omaliusi* and especially *Z. omaliusi*, var. *densa*, freely developed, and *D. charlestonensis* scarce, although from the above line of reasoning it might be expected that the latter would easily be the dominant form. And, further, in the Cement Stones (Tournaisian) of Liddisdale, where *Z. delanouei* is so (comparatively) abundant, only one of these corals has so far been found, and that, contrary to expectation, is an undoubted *D. charlestonensis*. It may be said that the evolution from *Z. omaliusi* was accelerated or retarded, as the case may be, in various districts. Such an hypothesis would certainly present an easy way out of the difficulty, though not a very acceptable one to the zonal investigator. All we can say at present is that while there can be no doubt of the genetic affinity of *Z. omaliusi* and *Z. omaliusi*, var. *densa*, on the other hand it is not certain that the affinity extends to *D. charlestonensis*, the latter being possibly a homœomorphic form.

(*To be concluded in our next Number.*)

VI.—Facts observed by Lieut. Damant, R.N., at the Sea-bottom.

By Arthur R. Hunt, M.A., F.G.S.

TAKING into consideration the apparently hopeless tangle in which the ripplemark and submarine erosion questions had become involved, I submitted to the Devonshire Association in July last a paper entitled "The Ripplemark Controversy," in which I attempted to bequeath the subject to posterity in such a form that anyone interested in the enquiry could pick it up where it had been dropped. It was, at any rate, my own farewell, or was so intended to be.

Last summer, however, in the progress of night manœuvres, the torpedo boat No. 99 was—fortunately, in the interests of science—sunk in 25 fathoms off Torbay. The vessel was recovered, and beached in Torbay. My curiosity was excited as to whether the divers could elucidate any of the submarine problems; but naturally, men only incidentally employed about the salvage could give me no information, and I hesitated to trouble the officers, besides being uncertain to whom I might apply. However, when Lieut. Damant, R.N., was appointed as a special officer to instruct divers, and as I knew he had been engaged in the salvage of No. 99, I finally decided to lay the case before him. The result has been that, instead of my taking leave of ripplemark and the physics of the sea-floor, ripplemark has abruptly taken leave of me.

Lieut. Damant has scarcely appreciated the importance of his evidence, and as he has never contemplated publishing anything on the subject, I am going to ask the hospitality of the Geological Magazine to secure for our distinguished diver national priority for his observations.

I may observe that in the Blue-book on Marine Erosion, just published, Mr. Aubrey Strahan, on being requested to furnish information on submarine disturbance, could find nothing better than

two conflicting authorities, derived, one from an old provincial paper of my own, and the other from "The Sea Coast" of my friend Mr. W. H. Wheeler, M. Inst. C. E.

Mr. Wheeler declares that "when there is considerable wave-motion on the surface of the sea at a depth at which divers are able to work the water is found to be motionless" ("The Sea Coast," p. 15). But he further asserts that "wind-wave action extends a very little way below the surface" (Coast Erosion, Question 4290). The formula given me by Lord Rayleigh, in the paper referred to, enables anyone to calculate what submarine disturbance is caused by any wave of known dimensions, and the depth to which it extends. I have myself been collecting information on this general subject since 1871, and have often pointed out the apparent certainty that the bottom down to about 50 fathoms must be appreciably disturbed by wave-currents if the records of the lengths and heights of waves are correct. My own collected evidence stopped short at a sounding which by the chart is somewhere between 36 and 41 fathoms. The evidence was a rolled and partially incrusted soda-water bottle, which was exhibited to Section C at Southampton in 1882, and has since been exhibited at a professional meeting of engineers to illustrate a professional paper.

The facts on which I have chiefly insisted have been the influence of alternate wave-currents on the marine fauna, and on erosion and deposition; also the independent and combined effects of tidal currents. My arguments were necessarily based on experiment, on sea and river observation, and on the authority of physicists. As Lieut. Damant has been down to 35 fathoms, and assures me that there is no difficulty in 30 fathoms, the physics of the shallow seas will obviously become a subject of ordinary observation, freed from the perils of induction, speculation, and conjecture. As a matter of fact, my own work of 36 years has been superannuated before it has even been accepted as sound. The following observations tell their own tale:—

"H.M.S. 'Excellent,' Portsmouth.

"I have seen sharp, well-defined ripplemarks upon sand at from 8 to 10 fathoms . . .

"On the theory of the adaptation of certain gasteropodous shells in shape and arrangement of spines to a form difficult to capsize on a flat surface being due to the necessity of providing against fairly violent water movements, I have often watched the state of affairs down below; a gentle rhythmical swaying movement (in the vertical plane) of shreds of weed, sprigs of polyzoa on stones, and the flexible tubes of various worms is always noticeable at 12 fathoms and perhaps more. . . . (Signed) "G. C. C. Damant.

"*12th October*, 1907."

"H.M.S. 'Excellent,' Portsmouth.

". . . . the tide on the bottom certainly is not a steady horizontal sweep; it seems to come curling and twisting along in 'gusts,' but this is only an impression. When hanging on, prone on the bottom to prevent being swept away by a too strong tide, one is accustomed to hear the sharp pattering on one's helmet of a regular hailstorm

of shingle and *small* stones; this is not continuous, but occasionally gusts of it come along, probably associated with upward currents.

"In Loch Striven, a deep narrow inlet on west coast of Scotland, near Kyles of Bute, specially chosen for deep diving experiments owing to the absence of perceptible tide, I found impalpable mud, not 'set' but almost in suspension on the bottom at 35 fathoms. It flew up in a cloud when one set foot on the ground, and altogether cut off what little light there was. (Signed) "G. C. C. Damant.

"*27th November*, 1907."

"Island Sailing Club, Cowes.

". . . Yes, I and another, a gunner, went down to 35 fathoms as a maximum at Loch Striven. I have often been at 30. . . .

"The sand round No. 99 torpedo boat the other day—you know where she lay—seemed utterly bare and lifeless. I saw one 'whelk,' and he looked absurdly lonely. . . .

". . . on that occasion of seeing ripplemarks in sand at about 12 fathoms, I remember being very much struck by the isolated chunks of rock, of about 10 lbs. I should judge, with weed on them, which stood on, rather than stuck up out of, the sand. There was a fair sea on, too much for our targets to stand. . . . shot were to be seen *on* the bottom, but, of course, they may have only just been fired. (Signed) "G. C. C. Damant.

"*29th November*, 1907."

In these conversational records of incidental observations Lieutenant Damant has unconsciously decided some hotly debated questions, and suggested several topics that might occupy the minds of physicists, geologists, zoologists, and engineers. My own feelings may be better imagined than described. They are analogous with what, I presume, those of an astronomer would be who had chanced upon a celestial visitant from comet and nebula, who just incidentally mentioned all the facts concerning those bodies which had perplexed and divided astronomers for generations. What has greatly astonished myself is that Lieut. Damant's attention should have been called to some of my own special puzzles, e.g. that of blocks lying on sand. Blocks of half a ton or more lie on the sandy bed of the English Channel off the coast of South Devon, and the trawlers occasionally take them in their nets. (See an example in the Museum of the Torquay Natural History Society.)

I should esteem it a great favour if this article were published, for otherwise the foreigners are sure to cut us all out, as they did in the case of the evidence of Kent's Cavern and the Antiquity of Man. That great fact was decisively proved in 1846 by the Torquay Natural History Society, following up the earlier researches of the Rev. J. McEnery, but the report of the explorers could find no publication except in the columns of a local visitors' directory, of which publication, I believe, there are but two copies in existence, though I have reprinted the report at my own charges.

So far as I can at present see, Lieut. Damant's observations have confirmed rather than disproved induction by tank and formula.

REVIEWS.

I.—Royal Commission on Coast Erosion.

Minutes of Evidence and Appendices thereto accompanying the First Report of the Royal Commission appointed to inquire into and to report on certain questions affecting Coast Erosion and the Reclamation of Tidal Lands in the United Kingdom. Vol. i, parts 1 and 2. 1907.

THE Commission was appointed on July 9th, 1906, and its first meeting was held on July 24th. The members comprise the Hon. Ivor C. Guest, M.P. (Chairman), Sir William H. B. ffolkes, Bart., Sir Leonard Lyell, Bart., Sir William Matthews, K.C.M.G., W. P. Beale, Esq., K.C., M.P., F.G.S., Commander G. C. Frederic, R.N., H. Rider Haggard, Esq., Professor T. J. Jehu, M.D., A. L. Lever, Esq., M.P., R. B. Nicholson, Esq. (Town Clerk of Lowestoft), P. O'Brien, Esq., M.P., T. Summerbell, Esq., M.P., and A. S. Wilson, Esq., M.P.

The Terms of Reference were as follows:—

To inquire and report—

(*a*) As to the encroachment of the sea on various parts of the Coast of the United Kingdom, and the damage which has been or is likely to be caused thereby; and what measures are desirable for the prevention of such damage:

(*b*) Whether any further powers should be conferred upon Local Authorities and owners of property with a view to the adoption of effective and systematic schemes for the protection of the Coast and the banks of tidal rivers:

(*c*) Whether any alteration of the law is desirable as regards the management and control of the foreshore:

(*d*) Whether further facilities should be given for the reclamation of tidal lands.

Part 1 of the First Report (5 pp., price 1*d.*) merely gives the notification of the issue of the Commission, and a statement that 27 meetings had been held and 56 witnesses examined. Part 2 contains Minutes of Evidence, with Index, 501 pp.; and Appendices with Index, 516 pp. (price 8*s.* 9*d.*). Here, indeed, is abundant, nay voluminous, material for study in the form of 11,367 questions and answers, and copious appendices.

Officers of the Board of Trade, of H.M. Woods and Forests, the Duchies of Lancaster and Cornwall, the Board of Agriculture and Ordnance Survey, the Local Government Board, and the Geological Survey were examined; likewise sundry local officials, other professional geologists and engineers.

There is no doubt that great and serious erosion is taking place along certain portions of the coast of England, notably between Bridlington and Kilnsea in Holderness; at Cromer, Happisburgh, and Caistor in north-east Norfolk; at Lowestoft, Kessingland, Pakefield, and Southwold in Suffolk; in Essex and Kent; at Rottingdean in Sussex; at Freshwater in the Isle of Wight; by Poole Harbour and at Lyme Regis in Dorset; and at Watchet in Somerset.

Remarkable evidence was, however, given by Colonel R. C. Hellard, Director General of the Ordnance Survey, to the effect that during the past 20 to 25 years there has been an actual gain of land of rateable

value to England and Wales of 30,752 acres; the total gain being 31,171 acres, and the net loss 419 acres. In this estimate the foreshore, or the area between ordinary tide-marks, is not reckoned as part of the land; but the loss in the amount of foreshore, principally due to artificial reclamation, is estimated at 31,000 acres.

Among the particulars given in reference to the gain and loss of acreage in counties during about 35 years, the following are of special interest:—

	Loss.	*Gain.*		*Loss.*	*Gain.*
Yorkshire	774	2178	Kent	526	519
Lincolnshire ...	400	9106	Sussex	374	1018
Norfolk	339	3480	Hampshire ...	198	852
Suffolk	518	151	Dorset	35	52
Essex	168	562	Somerset	33	256

It was admitted that a certain amount of the reclaimed land is still under water at high-tide spring-tides.

Suffolk has suffered the greatest loss of any county in England and Wales, and Southwold in particular has been a great sufferer in recent years.

The Board of Trade have no power to construct works to protect the coast; all they can do is to prevent, if necessary, the removal of shingle or other beach materials.

It is admitted that land protected in one place may mean loss in another. Individual rights may thus be opposed to the general benefit. There is thus need of general control on the coasts with regard to the removal of shingle or stone from foreshore, and to the erection of groynes and sea-walls. There is much information regarding groynes constructed of wood, ferro-concrete, chain-cable, and sheet-iron. The utilization of chain-cable is interesting, as possibly it may act as a nucleus for the formation of a protective iron-pan or conglomerate.

Much interesting information was given on the movements of beach material, as influenced mainly by wave action due to prevailing winds, and partly by flood-tides. Each district, however, has to be studied independently in connection with local circumstances, for on parts of the Cumberland coast the beach material is moved by the flood-tide from N. to S., in a direction contrary to the prevailing wind. In heavy gales, of course, the movement is in the direction of wind and sea.

In the Channel the drift is mainly from west to east, but the strength of the ebb-tide is said to be, if anything, greater than that of the flood-tide. On the west side of Selsea Bill the shingle is moved from east to west.

The influence of the lateral movement of water manifested by the breaking of waves is said to extend to a depth of at least 40 fathoms.

There is considerable travel of heavy shingle in moderately deep water of 5 to 10 fathoms, where there are strong bottom-currents. Indeed, material is said to be moved in depths up to 40 fathoms, but the enormous displacements in shoals off the eastern coasts do not appear to take place below 5 fathoms. It is clear that we have much yet to learn of the transport of shingle, etc., along the sea-bed below low-tide.

Thus the material of the foreshore was considered rightly to be not wholly derived from the waste of adjacent cliffs, but opinions differed

as to the amount of material that is thrown up from the bed of sea below low-water.

It was admitted that much scouring takes place off shore and that shingle travels below low-water mark. It was said to pass Beachy Head on to Dungeness, and the opinion was even expressed that no natural headland in the country completely arrests the travel of shingle.

On the other hand, it was asserted that stones in bays do not get out, that the shingle was retained in compartments between headlands. Here the Chesil Bank came in for discussion, and the old question was revived whether the Budleigh Salterton pebbles, which form a small portion of the material, came direct from the Devonshire cliffs, or were derived from a former raised beach of which tiny remnants still exist. Here it may be observed that no Budleigh pebbles are known to occur in the Tertiary (Eocene) gravels.

Incidentally other questions of geological interest arose, with regard to the warp of the Humber, and "Is clay a mineral?"

Geological evidence on the waste of particular portions of the coastline in England and Wales was given in order as follows, by W. Whitaker, Clement Reid, H. B. Woodward, C. Fox-Strangways, G. A. Lebour, A. Strahan, J. R. Ainsworth Davis, S. H. Reynolds, R. H. Worth, T. V. Holmes, and T. Mellard Reade (by Memorandum).

We look forward with interest to further information on the important subject of Coast Erosion, and to the conclusions at which the members of the Royal Commission after their long and patient labours will arrive.

II.—Geological Survey of Ireland.

The Geology of the Country around Limerick. By G. W. Lamplugh, F.R.S., S. B. Wilkinson, J. R. Kilroe, A. McHenry, H. J Seymour, and W. B. Wright. Dublin: printed for H.M. Stationery Office by Alex. Thom & Co., 1907. 8vo: pp. vi, 119, with 7 plates and 11 text-illustrations, price 2*s.*; with colour-printed map, price 1*s.* 6*d.*

We have received from the Board of Agriculture and Fisheries, Whitehall, the above memoir, which has been prepared by the Geological Survey of Ireland under the Department of Agriculture and Technical Instruction for Ireland. It is the last of four memoirs, the result of field-work carried out under the superintendence of Mr. Lamplugh, prior to the severance of the Geological Survey of Ireland from that of Great Britain. The preface is therefore written conjointly by Dr. Teall and Professor Grenville Cole.

The value of a detailed Drift map is amply shown in the colour-printed sheet which accompanies this memoir. Nevertheless, it must be admitted that in an area where the 'solid' rocks appear only in comparatively small and isolated tracts, it would be difficult to grasp the underground structure without the aid of the section at the foot of the map, or without the earlier hand-coloured sheets on which the 'solid' rocks were distinctly shown. The section shows how the dominant features of the country were pre-Glacial.

The older rocks include Silurian, referred to the Llandovery division; also Upper Old Red Sandstone, conformably overlain by the Carboniferous, with which are included sundry volcanic rocks. The greater portion of the area is underlain by the several divisions of the Carboniferous Limestone series, comprising shales and limestones, the latter in places oolitic, cherty, and dolomitic. The highest shale division is grouped with the Yoredale Beds, and the overlying flagstone series with the Millstone Grit. These strata were originally classed as Coal-measures, but no coal appears ever to have been found in them. The igneous rocks in the Limestone series are due to contemporaneous volcanic action, and, although interbedded, Mr. Kilroe believes that many of the lavas are intrusive in the tuffs and ashes associated with them. Petrological notes are contributed by Mr. Seymour. With regard to the physical features, it may be mentioned that the Old Red Sandstone of the Cratloe Hills on the north rises to a height of a little more than 1,000 feet, and the volcanic rocks of Knockroe in the south rise to 672 feet.

More detailed accounts are given of the superficial deposits, which include Boulder-clay, Glacial Sand and Gravel, and Alluvial deposits. To these descriptions Mr. Lamplugh contributes a general introduction, and it may be safely averred that much of the work of his colleagues is due to his inspiration. He has in fact left indelible traces of his wide experience on Glacial phenomena in the several Irish memoirs with which he has been connected. We learn that the Boulder-clay is the direct product of an ice-sheet which invaded the country in a general direction from north-west to south-east; and that while most of the included rock-fragments are local, yet with them are occasional boulders of granite which may be traced to a parent source on the north side of Galway Bay.

The position and arrangement of the stratified glacial gravel and sand is shown to be incompatible with marine agency, and it is held to represent the material of the ice-sheet modified by fluvio-glacial action. The greater part, if not the whole of the area, appears to have undergone glaciation, but only the minor features have resulted from this and subsequent action. Thus the Basin of the Shannon, which, in the area of the map, extends from Castleconnell to Bunratty and Mellon Point below Limerick, occupies a course that must be regarded as essentially post-Glacial. Any pre-existing channels in this area are concealed by the covering of Drifts.

An interesting feature on the map is the indication of the general characters of the soils on each subdivision, whether solid or drift. To this subject Mr. Kilroe has given special attention, and it is necessary to qualify the indications above given by his observations. Thus he mentions that the boulder-clay, "represented by one tint on the map, is present in at least five distinguishable varieties, which yield correspondingly different soils and subsoils." It would obviously be impossible to indicate such minor changes on a one-inch map. Other topics of economic interest are duly discussed, and the work concludes with a useful bibliography.

III.—A Text-book of Palæontology.

Einführung in die Paläontologie, von Dr. Gustav Steinmann, Ord. Professor der Geologie und Paläontologie an der Universität Bonn. Zweite, vermehrte und neubearbeitete Auflage, mit 902 Textabbildungen. Leipzig: Wilhelm Engelmann, 1907. Price, marks 15.20, bound.

THE first edition of this work (not to be confounded with Steinmann and Döderlein's "Elemente der Paläontologie," 1890) appeared in 1903, and consisted of 466 octavo pages with 818 figures. The second edition consists of 542 pages (9½ × 6¼ inches) with 902 figures. In the new edition 62 pages are devoted to Palæobotany, of which 7 deal with Dicotyledons, which occupied half a page in the first edition. Insecta, to which only two-thirds of a page were allotted previously, are now described by A. Handlirsch, of Vienna, in 14 pages; Reptilia occupy 29 as compared with 23, and Mammalia 53 as compared with 38½ pages.

Since the late Professor Karl A. von Zittel wrote his great "Handbuch" and his smaller "Grundzüge der Paläontologie," the fault of most text-books of palæontology has been that they are often little better than systematically arranged descriptive catalogues of fossils, written with very little reference to evolution, by drawing attention to which the dry bones may have some living interest imparted to them. The distinguishing feature of the present work is the attention which the author draws to the probable phylogeny of the forms described, although the arrangement remains systematic for facility of reference. Whether one agrees with the author or not, his views on the relationship of genera (and higher groups) to their supposed ancestors and descendants are always interesting. Perhaps the most remarkable of his suggestions is that the Tertiary marine mammalia are descended from the Secondary marine reptilia, viz., the Delphinidæ from the Ichthyosauria, the Physeteridæ from the Plesiosauria, and the Mystacoceti from the Thalattosauria (Pythonomorpha). Professor Steinmann read a paper on this subject before the Seventh International Zoological Congress at Boston in August last. In a final summary (in his book) Professor Steinmann draws attention to the supposed frequent sudden extinction and equally sudden first appearance of some of the important groups of animals, and arrives at the conclusion that the usual systematic arrangement of plants and animals has nothing to do with the phylogenetic connection between the separate forms, but rather obscures it, because the systematic do not coincide with the genetic lines, but cut across them.

Among fossil plants, he says, if we regard the mode of reproduction on which the systematic arrangement is based as a feature which may undergo change, and the purely morphological characters of mode of branching, form, venation, and arrangement of leaves as relatively persistent characters, groups are arrived at which are much less forced than those based on systematic arrangement. So also, if the four classes of quadrupeds Amphibia (+ Stegocephalia), Reptilia, Aves, and Mammalia are regarded, not as phylogenetic units, but as different stages of organization which have been reached or passed through in

more or less similarly directed progress by numerous series of phyletic stems already existing at the end of Palæozoic times, their evolution presents itself as a relatively simple and clear process of metamorphosis in which there is no space for large groups to either appear or become extinct abruptly. B. Hobson.

IV.—Geological Guide to the Neighbourhood of Vienna.

Geologischer Führer für Exkursionen im inneralpinen Becken der nächsten Umgebung von Wien. Von Dr. Franz X. Schaffer. Sammlung geologischer Führer XII. Sm. 8vo; 11 Abbildungen im Text. Gebrüder Borntträger, Berlin, 1907.

THIS is another of the excellent little Geological Guides issued by the Brothers Bornträger. The idea of writing this one occurred to the author when he was preparing for the excursions in the neighbourhood of Vienna in connection with the meeting of the Geological Congress in that city in 1902. The material for the work was already in the author's possession in his "Geologie von Wien" (part ii). Naturally only a few of the most important of the excursions could be dealt with in the small work under review.

Beginning with a brief bibliography of the subject, the author continues by giving the geological history of the Vienna Basin, which he calls the concluding episode in the formation of the Alps; that great chapter in the shaping of the physical contour of Europe, which has always had a particular attraction for students.

Let us depict in brief terms its past history as the author gives it, though but few traces remain by which the picture may be clearly presented to the mind's eye.

The Mediterranean had entered with its rich fauna into the sinking region, and in this area fresh-water beds were deposited before it had sunk below the level of the sea. The shore lay at a somewhat higher level than that at which its shore formations now stand. An immense portion of this inland sea was cut off from the ocean, and under the influence of inflowing fresh water a brackish-water fauna came into existence, and this can be traced up to the highest beds deposited near Vienna. While the transition from the marine to the Sarmatian stage is marked by a discordance or break in the succession of the beds connected with the retreat of the sea, the Sarmatian beds merged gradually into the Pontian, and the sea-level reached the same height as at the Mediterranean stage. The very thick beds of at least 500 metres (1,640 feet) in thickness mostly indicate a medium depth of water, the deposit having taken place on a slowly sinking sea-bottom. During the Pontian period a sinking of the water-level is noticeable, and at the same time a stream coming from the north-west finds its way into the basin. In Vienna its traces are not only seen in the high-level terraces, but also in the thick 'schotter' (conglomeratic deposits) which the stream has brought down here to the margin of the sea. The terraces can be traced near Vienna at heights ranging from 50 to 200 metres above the present level of the Danube, and they stretch still farther south of this area. Loess and also fresh-water limestone were deposited at about this period at the edge of the

basin. The smaller watercourses coming from the marginal hills blended their schotter with the fresh-water limestone, and the transition to the present time is so gradual that the dividing-line cannot be recognized. While in the more central part of the basin immense masses of sediment have been deposited, those of the margin are very much thinner. Erosion alone can have created the present geological conformation.

This little work is well illustrated by means of natural sections, reproduced from photographs, and by numerous diagrammatic sections in the text. There are also many tables of characteristic fossils.

A. H. F.

V.—Summary of Progress of the Geological Survey of Great Britain and the Museum of Practical Geology for 1906. 8vo; pp. 181, with three text-illustrations and one plate. London, 1907. Price 1*s*.

THIS number of the "Summary of Progress," which was issued in the autumn, is less in bulk than its predecessor by more than twenty pages: a reduction due not to the fact that the publication is for the first time notified as "of Great Britain," instead "of the United Kingdom," but to the shorter record of field-work in Scotland. Progress has been made with the mapping of the Highland Schists, but at present "the difficulties of interpretation and correlation appear to increase rather than diminish," and "no general theory as to the structure or sequence of rocks has been formed on which all officers are agreed." The rocks of the Lizard area have been undergoing detailed examination, and they too have presented problems not yet solved, as their relations with the Devonian and earlier sedimentary strata on the north have yet to be demonstrated. Elsewhere in Cornwall, as also in the coal-fields of South Wales, Derbyshire, and Scotland, and in the adjacent tracts of older and newer strata, the work has proceeded in areas often of much difficulty, but without those conflicting opinions which beset the crystalline schists. The zonal distribution of fossils has received special attention in the Ordovician, Silurian, and Carboniferous rocks of Pembrokeshire, and in the Carboniferous of Scotland, and has not been neglected in other regions. Economic geology rightly occupies some space—in the details of coal-bearing strata in England, Wales, and Scotland, in remarks on the eastern extension of the Nottinghamshire coal-field, in the account of the fluor-spar of Derbyshire, and in the suggestion made that bordering Cornwall "There must be a large amount of detrital tin-ore at the bottom of certain of the bays margined by rich tin-lodes."

In the Appendix there is an essay on "The Scapolite-bearing Rocks of Scotland," by Dr. J. S. Flett; a statement of the "Total quantity of Tin, Copper, and other Minerals produced in Cornwall, particularly with regard to the Quantities raised from each Parish," by D. A. MacAlister; and detailed records of "Some Well-sections in Middlesex," by W. Whitaker and George Barrow.

VI.—The Cotteswold Naturalists' Field Club.

THE Proceedings for September, 1907, being part 1 of vol. xvi, contain a record of the excursions of this Club during 1906, and of the Winter meetings of 1906–7. An interesting excursion to the Lickey Hills was made under the direction of Professor Lapworth, and another notable excursion, in celebration of the 60th Anniversary of the Club, was made to Bourton-on-the-Water and Burford. Among the papers published is one by Mr S. S. Buckman on "Some species of the genus *Cincta*." Of these the genotype is *Terebratula numismalis*, Valenciennes, afterwards known as *Waldheimia numismalis*. Two plates are given to illustrate this and nineteen other forms of *Cincta*. Another paper of considerable interest is by Professor C. G. Cullis and Mr. L. Richardson, entitled "Some remarks on the Old Red Sandstone Conglomerate of the Forest of Dean and the Auriferous Deposits of Africa." During the course of last year some stir was made in the newspapers about a discovery of gold in a locality about 200 miles distant from London. The locality is in the Old Red Conglomerate about one and a half miles south-west of Mitcheldean Road Station. The authors report that a small amount of both gold and silver do occur, "but it still remains to be proved that the gold occurs in any part of the rock, either at or below the surface, in sufficient quantity to be workable with profit."

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.

I.—*November 20th*, 1907.—Sir Archibald Geikie, K.C.B., D.C.L., Sc.D., Sec. R.S., President, in the Chair.

The following communications were read:—

1. "Glacial Beds of Cambrian Age in South Australia." By the Rev. Walter Howchin, F.G.S., Lecturer in the University of Adelaide.

The known extension of the beds in question is 460 miles from north to south (Onkaparenga River to Willouran Range). The greatest width across the strata between Port Augusta, at the head of Spencer's Gulf, in an easterly direction to the Barrier Ranges of New South Wales, is about 250 miles. The beds occur as part of a great conformable series, in the upper part of which Cambrian fossils have been found. The rocks above the glacial beds are mainly purple slates and limestones; below they are quartzites, clay-slates, and phyllites, passing into basal grits and conglomerates, resting on a pre-Cambrian complex. The beds consist of a groundmass of unstratified indurated mudstone, more or less gritty, carrying angular, subangular, and rounded boulders, up to 11 feet in diameter. In most sections there are more or less regularly stratified bands. The thickness of the glacial series has been proved up to 1,500 feet. The commonest rock-type among the boulders is a close-grained quartzite; but gneiss, porphyry, granite, schistose quartz, basic rocks, graphic granite, mica schist, and siliceous limestone occur. The discovery of ice-scratched boulders has placed the origin of the beds, according to the

author, beyond doubt. The striæ are often as distinct and fresh-looking as those occurring in a Pleistocene boulder-clay. Up to the present eighty definitely glaciated boulders have been secured, besides the known occurrence of other erratics too large for removal. Under strong pressure and movement in their bed, some of the boulders exhibit evidences of abrasion; but this produces features which cannot well be confounded with those due to glaciation. The pressure that has induced cleavage has caused the elongated boulders to revolve partly in their bed and place their long axes parallel to the cleavage-planes. In this movement some of the stones have become slightly distorted, and many show the effect of fracture in the form of pseudo-striation on exposed surfaces. The lines, however, are of equal size and depth, and parallel to each other over wide surfaces; while the glacial striæ are generally patchy in their occurrence, of varying intensity, and divergent in direction. A series of illustrative sections are described. It is considered that Mr. H. P. Woodward's suggestion, that the 'boulder-clay' had its origin from 'floating ice,' appears to be most in accordance with facts. The interbedded slates and limestones may possibly indicate the occurrence of interglacial conditions.

2. "On a Formation known as 'Glacial Beds of Cambrian Age' in South Australia." By H. Basedow and J. D. Iliffe. (Communicated by Dr. J. Malcolm Maclaren, F.G.S.)

Some 8 miles south of Adelaide a typical exposure of the conglomerate is bounded to the east by a series of alternating quartzitic and argillaceous bands of rock, comprising the central and western portions of a fan-fold, partly cut off by a fault. Further evidence of stress in this margin is given in the fissility, pseudo-ripplemarks, contortion and fracture, and obliteration of bedding in the quartzite bands, and in the pinching-out of them into lenticles and false pebbles. On the west side the conglomerate is bounded by the "Tapley's Hill Clay-Slates," and there is evidence from the nature of the junction beds that the conglomerate itself is isoclinally folded. In that portion of the conglomerate which is adjacent to its confines, 'boulders' of quartzite are apparently disrupted portions of quartzite bands, since these are in alignment with the truncated portions of bands still existing, and are of similar composition. The authors are not at present in a position to account for the presence in the conglomerate of boulders of rocks foreign to the beds that border the conglomerate, or of such as possess markings comparable to glacial striæ, by their theory of differential earth-movements; but they consider that a boulder-bed subjected to lateral pressure would probably lend itself to the production of 'false pebbles,' through the disruption of intercalated hard bands within itself or on its boundaries.

II.—*December 4th*, 1907.—Sir Archibald Geikie, K.C.B., D.C.L., Sc.D., Sec. R.S., President, in the Chair.

The following communications were read:—

1. "The Faunal Succession in the Carboniferous Limestone (Upper Avonian) of the Midland Area (North Derbyshire and North Staffordshire)." By Thomas Franklin Sibly, B.Sc., F.G.S.

The area dealt with is the irregularly-shaped periclinal mass forming the southern end of the Pennine anticline, with a few small outliers. The base of the limestone is not shown, and the whole series exposed constitutes a greatly expanded development of the uppermost zone of the typical Avonian succession of the South-Western Province, namely, the *Dibunophyllum*-zone. The most extensive section—that along the Midland Railway, between Longstone and Buxton—shows a thickness of about 1,500 feet. Three subzonal divisions are distinguished, as follows:—

D_3. Subzone of *Cyathaxonia rushiana*: represented in the South-Western Province by horizon ϵ and the lower part of the Millstone Grit.

D_2. Subzone of *Lonsdalia floriformis*: correlated with the Upper *Dibunophyllum* zone (D_2) of the South-West.

D_1. Subzone of *Dibunophyllum* θ: correlated with the Lower *Dibunophyllum* zone (D_1) of the South-West.

An abnormal development of the *Lonsdalia*-subzone, consisting of richly fossiliferous Brachiopod beds, in which the typical coral fauna has very little representation, forms a conspicuous local feature in various parts of the western half of the area. The passage-beds between the Carboniferous Limestone and the Pendleside Series are included in the *Cyathaxonia*-subzone. Locally, these passage-beds attain a thick development. A local unconformity between the Carboniferous Limestone and the Pendleside Series, indicating contemporaneous elevation and erosion, occurs in the eastern part of the area. A close general similarity exists between the *Dibunophyllum*-zone of the Midland area and that of North Wales. These two areas should be regarded as constituting a Midland Province. A comparison of the *Dibunophyllum*-zone of the Midland with that of the South-Western Province brings out the following more important differences:—(*a*) The Brachiopod fauna of the *Lonsdalia*-subzone of the Midland Province is considerably richer than that of the equivalent part of the South-Western sequence. (*b*) The *Cyathaxonia*-subzone of the Midland Province, which attains a maximum development in Derbyshire and North Staffordshire, is practically undeveloped in the South-Western Province.

The paper concludes with a description of certain corals and Brachiopods from the Midland area, some species and varieties being new.

2. "Brachiopod Homœomorphy: '*Spirifer glaber*.'" By S. S. Buckman, F.G.S.

The smooth, catagenetic, stage of shells may have been attained by the loss of different distinctive features, pointing to polygenetic origins. The series of shells figured by Davidson as *Spirifera glabra* do not all agree in being smooth; some are radially costate, some have a pronounced mesial fold, others hardly any, some are very transverse, others are narrow. There is good evidence that several of the forms ranged under this species are *Reticulariæ* (M'Coy), more or less smooth. Thus *Sp. obtusus*, regarded by Davidson as a synonym of *Sp. glabra*, shows faint reticulation, has the dental plates, and must be classed as a *Reticularia*; while quite smooth forms with similar plates also occur (*Sp. lata*, Brown, and *Sp. glaberrimus*, de Koninck). But other forms

called *Sp. glabra* seem to have been derived from radially costate ancestors. The use of the generic name *Martinia* for various smooth Spiriferids of the Devonian and Carboniferous thus becomes wholly unjustifiable, as it simply denotes a stage of catagenetic development at which several different stocks of Spirifers arrive. As the outcome of this study the author restricts the genus *Spirifer*, and allocates several British and foreign species among the genera *Fusella*, *Choristites*, *Trigonotreta*, *Brachythyris*, *Martinia*, and *Reticularia*. He also gives in an appendix a revised explanation of Davidson's plates xi and xii of the Monograph of Carboniferous Brachiopods.

CORRESPONDENCE.

GLACIATION OF THE USK AND WYE VALLEYS.

Sir,—At the meeting of the British Association at York in 1906 a paper on the Glaciation of the Usk and Wye Valleys was read by the Rev. W. Lower Carter, and was printed in abstract in the Report (pp. 579–580). An abstract appeared also in the Geological Magazine (for 1906, pp. 521, 522). The author there records several interesting and important glacial phenomena, and it is to be hoped that he will find occasion to continue his researches. There is, however, one point on which it is necessary to register a *corrigendum*. After speaking of the purely local drift in the region (an Old Red Sandstone district) he calls attention to certain "erratics of volcanic ash and brecciated limestone" (B.A. Report), or "volcanic ash and breccia" (Geol. Mag.), which overlie the local drift; and he supposes them to be derived from distant Ordovician sources.

A recent visit—unofficial and connected with quite other matters—to the district enables me to say that the erratics of 'volcanic ash' and 'breccia' or 'brecciated limestone,' to be seen in the village of Trecastle and on the neighbouring hillsides, and again at Talgarth and along the course of the river Enig above the town are, in fact, boulders of *cornstone*, of both the conglomeratic and the non-conglomeratic variety; and that instead of being derived from distant Ordovician sources they are traceable to quite local outcrops of that rock in the valleys in which they occur. No doubt ice had much to do with their transport, but their journeys to their present resting-places were not so romantic as a derivation from Ordovician sources would involve.

T. C. Cantrill.

Geological Survey, Jermyn Street, S.W.
7th December, 1907.

RE SPELLING OF PLACE-NAMES.

Sir,—The slight demurrer offered by your reviewer of the Geological Survey Memoir on "The Geology of the Country around Ammanford" in the November number of this Magazine (1907, p. 515), as to the alteration of the spelling of the place-name 'Llandeilo' to 'Llandilo,' reminds me of an intention I had of enquiring, through the medium of your Magazine, the views of some of your readers as to the desirability

of altering the specific names of fossils derived from place-names so as to accord with the present rendering upon the Ordnance Survey Maps. The well-known Rhætic fossil *Pleuromya crowcombeia* (Moore) is given as *Pleuromya crocombeia*—the *w* is omitted—in the Geological Survey Memoir on "The Geology of the Country between Wellington and Chard" (1906, p. 27).

L. Richardson.

Cheltenham.
14th December, 1907.

NORTH DEVON ATHENÆUM: GIFT OF THE PARTRIDGE COLLECTION.

Sir,—This institution has recently received a most valuable gift, the large collection (Partridge Collection) of Devonian and Culm fossils made by Mrs. Coomaraswamy in North and South Devon, and by Dr. Coomaraswamy on the Continent. Included in the Partridge Collection are fourteen specimens figured in the Rev. G. F. Whidborne's Monograph of Devonian Fauna (Palæontographical Society) and the Geological Magazine, five of them type-specimens. This, added to T. M. Hall's already there, makes the North Devon Athenæum Collection one of the most complete of its kind in the kingdom. The specimens being too numerous to be all displayed, Dr. Coomaraswamy has made a selection, for the exhibition of which special cases have been provided; the remainder have been placed in drawers, and, like all the specimens in this Museum, are available for purposes of study.

Devonshire, even prior to this most liberal gift, was rich in local geological collections. It may now be said without exaggeration that the Museums at Exeter, Plymouth, Torquay, and Barnstaple, between them contain practically a complete collection of the fossils and rocks (so far recorded) of the county. J. G. Hamling.

The Close, Barnstaple.

OBITUARY.

THE RT. HON. WILLIAM THOMSON, BARON KELVIN,

P.C., O.M., G.C.V.O., LL.D., D.C.L.,

Past President of the Royal Society, etc.

Born June 26, 1824. Died December 17, 1907.

In the death of Lord Kelvin geologists have lost one who took keen interest in the physical and astronomical aspects of their science, and aided perhaps more than any other philosopher in this country to place the subject of Cosmogony on a scientific basis. He dealt with the evolution of the heavenly bodies, with changes in the position of the earth's axis of rotation, with the probable condition of the earth's interior, and with the thermal conductivity of rocks. In one respect his views regarding the earth found little support. His calculations on the increase of temperature beneath the surface and the rate of loss of heat from the earth led him in 1862 to argue, that the age of the

earth must be restricted to about one hundred million years; and he subsequently reduced the estimate to between twenty and forty million years.[1] Huxley, in one of his famous addresses to the Geological Society (1869), showed that while geologists had no reason to be greatly concerned at an estimate of 100,000,000 years, yet the data on which the restriction was based were insufficient and inconclusive. Further researches have not tended to modify this judgment.

William Thomson, Lord Kelvin, was the second son of James Thomson, Professor of Mathematics in the University of Glasgow, and the son became Professor of Natural Philosophy in the same University during the lifetime of his father.

Regarded as the foremost man of science in Britain, it was fitting that a final resting-place in Westminster Abbey should be selected, near the tombs of Newton, Herschel, Darwin, and Lyell; and there he was buried in the presence of a large and distinguished gathering on the 24th December, 1907.

MISCELLANEOUS.

British Museum Model of *Eurypterus*.[2]

In the Upper Silurian rocks of the island of Oesel, in the Baltic, are found the fossil remains of an Arthropod called *Eurypterus Fischeri*. This animal is of interest as one of an extinct group of Arthropods that appear to have been allied to the modern *Limulus* or king-crab, as well as to the Scorpions. These particular fossils have a further interest in that the chitinous substance of the outer coat of the animal has been preserved unaltered in chemical and physical composition. Thus Professor G. Holm, of Stockholm, has been able to dissolve the remains out from the rock by means of acid, and to mount them on glass slides in Canada balsam. On the preparations thus obtained he based an elaborate description, published in the Memoirs of the Academy of Science, St. Petersburg (ser. VIII, vol. viii, No. 2, 1898). It can now be said that the structure of this species is known better than that of any other extinct arthropod. Several of Professor Holm's preparations preserved in the Geological Department of the British Museum are quite marvellous, and it is difficult to believe that one is looking at a fossil at all, still more one dating from the Silurian epoch.

The perfection of these specimens and the interest of the animal suggested to members of the staff of the British Museum (Natural History) the advisability of preparing a complete model of it, and such a model in coloured wax, of about twice the natural size, has now been made under the direction of Dr. W. T. Calman and Dr. F. A. Bather by Mrs Vernon Blackman, whose beautiful models of plants, of the parasite of malaria, and of the tsetse fly are well known to all visitors to the Natural History Museum in the Cromwell Road.

[1] See Sir A. Geikie's Text-Book of Geology, 4th ed., vol. i, 1903, p. 79.

[2] From *Science*, November 15th, 1907, pp. 679–680.

The model was first placed on exhibition on the occasion of the visit of foreign geologists at the Centenary of the Geological Society of London and evoked their enthusiastic admiration. It measures 23 × 15 cm. The wax of which it is made will stand any extremes of temperature likely to be met with in a museum, and the colours are believed to be quite permanent; they are based upon those of the recent *Limulus*, and Sir Ray Lankester has shown great interest in their selection. The model, which, it may be mentioned, has been subjected to the careful scrutiny of Professor Holm himself, certainly looks quite as natural and lifelike as any specimen of a recent Arthropod exhibited in the museum.

The Geological Department hopes to have a limited number of copies of this model, which it will be prepared to exchange with other museums. Naturally a model of this nature, which has taken a very long time to make, demands an exchange of considerable value, but for information on this matter inquiries should be addressed to Dr. A. Smith Woodward, F.R.S., the Keeper of the Geological Department, Natural History Museum, Cromwell Road, London, S.W.

Royal Medal to Dr. R. H. Traquair, F.R.S., F.G.S.

In the Anniversary Address to the Royal Society by Lord Rayleigh on November 30th, 1907, the President said His Majesty has approved the award of a Royal Medal to Dr. Ramsay H. Traquair, F.R.S. Dr. Traquair is honoured on the ground of his long-continued researches on the fossil fishes of Palæozoic strata, which have culminated, within the past 10 years, in his discovery of new groups of Silurian and Devonian fishes, and in his complete exposition of the structure of *Drepanaspis*, *Phlyctænaspis*, and other remarkable forms. For nearly forty years Dr. Traquair has been busy with the description of fossil fishes, mostly from the Palæozoic rocks of Scotland, and he is deservedly held to be one of the most eminent palæontologists of the day. He has been highly successful in the interpretation of the often very obscure and fragmentary remains which he has had to elucidate, and his restorations of fishes have won such credit as to appear in all modern text-books of Palæontology. It may be said that his work, notwithstanding the great difficulties of the subject, has well stood the test of time. Dr. Traquair has done much to advance our knowledge of the osteology of fishes generally. His earliest memoirs on the asymmetrical skull of flat-fishes and on the skull of *Palæopterus* remain models of exactness. His acquaintance with osteology enabled him to show how former superficial examination of the Palæozoic fishes had led to wrong interpretations. He demonstrated that *Chirolepis* was not an Acanthodian, as previously supposed, but a true Palæoniscid. In 1877 he satisfactorily defined the Palæoniscidæ and their genera for the first time, and conclusively proved them to be more nearly related to the Sturgeons than to any of the other modern Ganoids with which they had been associated. He thus made an entirely new departure in the interpretation of extinct fishes, replacing an artificial classification by